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Baxter's C. P. — Matho: or the Cosmotheoria Puerilis, A Dialogue, by Baxter, but published without his Name 1740 in 2 Vols. 8.vo as a Translation ~~[illegible]~~ of a little Pamphlet formerly published by him under the like Title, in Latin.

W. J. The Rev.d M.r W.m Jones ~~[illegible]~~

Rowning, his Compendious System of Natural Philosophy. in 3 Vols. 8.vo

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Cochin Lat. 9.58.22 N.
Long. 76 26.30 E. 76°26'30"E.

Madrass Lat. 13.4.47.
{81.1.45 E
{79.40.0 E.}

Kalpee Lat. 26.8.35. N.
80.1.0 E.

Jalvin — 26.8.58 N
79.37.30 E

Pausore — 18.20.34 N.
74.8.0 E.

Bombay 18.55.22 N
72.45 30 E

23. 58. 10
11. 59. 5

24. 0. 50
12. 0. 25
1. 20
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23. 58. 9
11. 59. 4½

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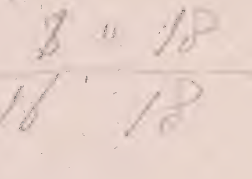

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1. A Body projected at a given Angle of Elevation from an Emenience on the Earth's Surface and with a Velocity sufficient to carry it beyond one fourth part of the Earth's Circumference, Quære the nature ~~[illegible]~~ and Length of the Curve described, and the time the body will be in Motion. The Solution hereto will lay bare the foundations of Newton's Philosophy, and make way for some striking instances of H.'s Philosophy.

2. How is a particle of spirit made from a particle, or particles of Light, since a particle or atom cannot be divided?

3. Are the Particles of all Matter as the density of the Mass's which they constitute? Or

4. Are the Constitutent Particles or Atoms of all Matter whatsoever, of the same density?

5. What may be the effect of Light mutually reflected from one Planet to another?

6. Will the Mosaic Philosophy allow and account for any Motion in the Aphelia of a Planet?

7. What is the Essential difference between ~~the~~ a Particle or Atom of Gold and another of steel?

8. Are Vegetables and Animals composed of particles like other Matter?

9. How and after what manner does a Vegetable or Animal grow, or receive an increase of Matter?

10. What is the immediate Cause an Operation of Animal Motion?

11. By what cause & operation did the Light on the 4th day's creation gather together in one place.

12. How did the Agents operate to put the Celestial Bodies first in Motion?

13. How is the bounds or limits of Flame or the Sun's body accounted for?

14. How does a body act upon another body in contact to produce Fire?

15. How is the friction from the Axis of a Mill prevented from producing Fire?

16. Is there not a certain limitation of Motion, or rather Action, to produce fire in all cases?

17. How does a large stagnant body swallow, as it were, the motion of a smal one, without being moved itself?

18. Since Iron is harder than Gold, hardness is not as the Solidity; is it therefore Cohesion, Or is it to be accounted for, from some bodies retaining more Light than others?

19. ~~[illegible]~~ If there be two equal Spaces, the one filled with Large Globes, and the other with small ones, which of the two will have the greatest or most intersticial Space? Ans.r neither will, for they will both be equal, as is shewn on p. 1.

20. Will not a Solution to the 19th Q. account for a dense body containing more Light than a rarer?

21. How do the Agents act and operate upon bodies or Matter retaining Heat? A Solution may perhaps afford some knowledge how the Celestial Bodies came first to move, at least it will give a secondary Principle, which ought to be well grounded.

22. A Body revolving upon its own Axis, as the Sun, and thereby sending out Matter, or Rays, in all manner of directions; Quære if this is consistant with Mathematic Mechanics.

23. The Sun's orb being an oblate spheroid, sending forth its Light in directions bounded or limitted by the Zodaic, and its circulation round the conjugate Axis, the opposite Sides of the System must be dark. Quære if this will not account something towards the Phenomena of Comets?

24. Does not the world now embrace and rest upon Mechanic motion, as founded on Matter to be put in ~~motion~~ action (therefore inert)? Ans. yet is it not truly founded on matter already in Action?

25. How does the Air or Wind operate upon a Ship to put it first in motion, and afterwards to continue that motion in almost all manner of directions?

26. How does the Air or Wind Act and Operate upon the Sails of a Wind mill to first put them in Motion and continue it? Also upon a Smoke-jack?

27. What are the Agents, and how do they Act and Operate to continue a Top in Motion, after the vis impressa has left it? V. Principia Newtoni, Lex. I. p. 12. also p. 92 of this M.S.
These three last are proposed with a view of gaining some, if not the whole, inlet of accounting for the first Action & Operations of the Agents to put the Celestial Bodies in

Standard Weight of Several Coins
From an old Box of Scales & Money weights of Mr. Croford & Mr. Wing

	Oz.	Pwt.	Gr.
A 5 Moidore Piece	1.	14.	15¼
One Moidore	..	6.	22¼
Half a Moidore	..	3.	11
A £3. 12 Piece	..	18.	10
A £1. 16. D°	..	9.	5
18 Shillings D°	..	4.	14½
9 Shilling D°	..	2.	7¼
A Guinea	..	5.	9
½ Guinea	..	2.	16½
* A Jacobus	..	6.	6
† A Carolus	..	5.	18
‡ A Pistole	..	4.	8

Objection to the time of the Deluge.

1st Answer.

Note, That each Grain of Gold is 2d, at £4 per Ounce.

* A Gold coin stamped in King James Ist a broad-piece 20s. value, now current at 23s. and the 22s. broad-piece, now current at 25s.

† A broad-piece of Gold of King Charles Ist made then for 20s. now current at 23s.

‡ A Gold coin struck in Spain & Italy, generally valued at about 16s. 6d sterling.

Jan.y 1769. The pound troy is divided into 44½ equal parts, each of which make a guinea. But according to the last proclamation, a guinea should weigh 5 Pwts 9 gr. & ½ a guinea 2 Pwts 16 gr. less than these are not passable.

Direction to the Society for the Encouragement of Arts &c.

Any Information or Advice, which may forward the designs of the Society (instituted at London for the Encouragement of Arts, and Manufactures and Commerce) for the Public Good, will be received thankfully, and duly considered, if communicated by letter directed to Dr Templeman, the Secretary, at the Society's Office, opposite Beaufort, in the Strand, London.

2nd Answer.

Among the Machines in the said Society's Repository, are these 5.

1. A Compass and Protractor, by Mr. Aaron Miller; for which he had a bounty of ten guineas, Feb. 11, 1767.
2. A Machine for taking Heights and Distances, by Mr. Grant.
3. An Expanding Rod for gauging vessels, by Mr. Efford; for which he had a bounty of twenty guineas, Apr. 22, 1767.
4. A Pair of Door-Hinges with Spiral Springs, by Mr. Delivitz; for which he had a bounty of fifteen pounds. Feb. 3, 1768.
5. A Model of a Crane, by Mr. Pinchbeck; for which he had a gold Medal, June 3, 1767.

West side of the Globe most warm & fertile. V. p. 60.

Heat increases a body's bulk & weight.

28. To come more closer to the Celestial motions than in the preceding Quores it will be proper to account for the beginning and continuation of the motion of Jones Machine and then add the application of this to the former, all which will undoubtedly reflect great light upon the Subject of Philosophy.

29. How is the double motion of an Electrified glass sphere, revolving round a brass ring, accounted for?

Part of T. Whites Letter Dated Oct. 6th 1759. is to this effect.

It is most certain that the four Seasons of the Year were all existing together every day throughout the whole year on the several Parts of the Earth, so that to account for the particular Season in wch. the Deluge happened, from Vegetables lodged in Fossils, lies beyond the reach of my present Comprehension.

Answered

Mr. White

Your objection to the evidence drawn from the relicks of the flood, is a very natural one: for as all the seasons exist at once, how can a fossil determine us to any particular one? In answer to this, you are to consider, that the seasons go with the Latitudes to the Northward and Southward -- But the course of the waters, by which the substances were carried about and deposited at last in the earth, was nearly to the eastward and westward, at which points, supposing the Lat. the same, the Seasons will be the same. which way do you think the tides would move if the globe were all fluid, and the current no where obstracted by continents? not Northward and Southward, but obliquely from the east to the west, nearly in the same course with the moon: and hence it is, that as the diurnal motion of the earth was contrary to the course of the waters, and the one acted against the other, the mountains and Sea coasts in general are steep and abrupt to the west and south-west in these northern parts of the world (being torn away and broken off by the waters) but gradual and flat to the east and north east -- These things considered, you will be satisfied your objection is founded on a mistake -- I am Sir

Your very sincere Friend W. Jones.

A verbal answer to the same objection given me by the same W. J.

The tides then continued and also the Rotation of the earth round its Axis, so that those plants lodged in fossils ~~prove the time of the Year in which~~ could not move far from the Latitude where they grew; for many Plants and fossils from north America are found in England but none from south America; by observation, the seeds of the same plant seem to be dispersed in parallels of Latitude only, and all mountains & Rocks are broken in the direction of East and West, only. Hence as fossils and plants are found here in england it follows the time of the Deluge was about the Autumnal quarter.

In a letter from Captain Barnardo, dated the 27th of June 1640, on the attempt of a N. W. passage, inserted in the New Universal mag. for March 1752, is the following remarkable narrative.

"The 14 of July we sailed out of the E. N. E. end of the lake de Fonte, and passed a lake I named Estricho de Ronquillo, 34 leagues long, 2 or 3 leagues broad, 20, 26, & 28 fathoms of water; we passed this streight in 10 hours, having a stout gale of wind and whole ebb. Qy. As we sailed more easterly, the country grew very sensibly worse, as it is in the north and south; the west differs not only in fertility but in temperature of the Air, at least 10 degrees; and it is warmer on the west-side than on the east, as the best Spanish discoverers found it, whose business it was in the time of the Emperor Charles V. to Philip III. as is noted by Alvares, & Costa, & Mariana, &c."

A Red hot iron gains $\frac{1}{10}$ of the whole in Bulk & Weight; for the fire lodged in the iron is languid or at rest, and therefore is not the Cause of Gravity, but itself becomes subj to Gravity; & consequently must weigh as well as the iron it is mixed with. Mr. Jones.

The quality of metals to conduct heat is in the following order, silver, gold, copper, tin, iron, steel, lead, and platina.

5) On the Measure of a degree in S. Latitude.

M. De la Caille[*], determined a distance of 410814 feet from a place called Klip-Fonteyn to the Cape of Good Hope, by means of a base of 38802 feet three times actually measured: whence he discovered a new secret of nature, viz., that the radij of the parallels in south latitude are not the same as those of the corresponding parallels in north latutude. About the thirty third degree of south latitude he found a degree on the meridian to contain 342222 Paris feet[*] between the years 1751 & 1754.

General (Martin's) Mag. Apr. 1764. in the Life of De la Caille, p. 180.

Reason why the Ante-diluvians lived longer than we do.

No rains, tempests, &c. but a petual spring before the flood.

Derivation of several ASTRONOMICAL and GEOGRAPHICAL TERMS.

ÆQUATOR or ÆQUINOCTIAL, because the sun coming to this Circle tunc æquantur Noctes & Dies.

AMPHISCIANS, ἀμφὶ utrinque, and σκιὰ umbra.

ANTIPODES, ἀντὶ contra, and ~~οἶκος habitatio.~~ πόδες pedes.

ANTOICI, ἀντὶ contra and οἶκος habitatio.

ARTIC, ἄρκτος, ursa; and ANTARTIC, ἀντὶ contra, and ἄρκτος, ursa.

ASTRONOMY, Ἀστρονομία Astrorum Distributio.

AXIS, ἄγω duco; quia circa illum Terra ducitur.

CLIMATE, κλίμα Declinatio, or Inclinatio.

CŒLESTIAL, Cœlum.

COLURES, κόλουροι Caudâ mutili (from κόλος mutilus, and οὐρά Cauda) quia imperfecte omnibus, qui sub Æquinoctiali —— non sunt, et tanquam Caudâ precisâ appareant.

Plants, by means of vapour, will grow without earth.

CONTINENT, Contineo.

(*) GEOGRAPHY, γῆ Terra & γραφὴ Descriptio.

GULPH, in Latin is Sinus, quia sinu suo Mare complectitur.

HETEROCIANS, ἕτερος alter and σκιὰ umbra.

HORIZON, ὁρίζων terminans; quia nostrum terminat Prospectum.

Copper & Brass Vessels pernicious

ISLAND, in Latin Insula, quasi in Salo.

ISTHMUS, εἰσίημι ingredior.

A LAKE, λάκκος Fossa.

MERIDIAN, Meridies.

MOUNTAIN, Mons a Monendo.

OCEAN, ὠκέανος ex ὠκέως cito & νάω fluo.

PENINSULA quasi pene Insula.

Dew ascends only.

PERISCIANS, περὶ circa and σκιὰ umbra.

PERIOICI, περὶ circum οἶκος habitatio

POLES, πολέω, verto.

PROMONTRY quasi promontorium vel Mons in Mare prominens.

A RIVER, ῥέω fluo.

SEA, Salum a Sale quia salsum.

SOLSTICE, Sol the sun & Stare to stand.

A STRAIT in Latin Fretum, a ferveo quod ibi ferveat Mare propter Angustiam.

TERRAQUEOUS, Terra the earth & Aqua the water.

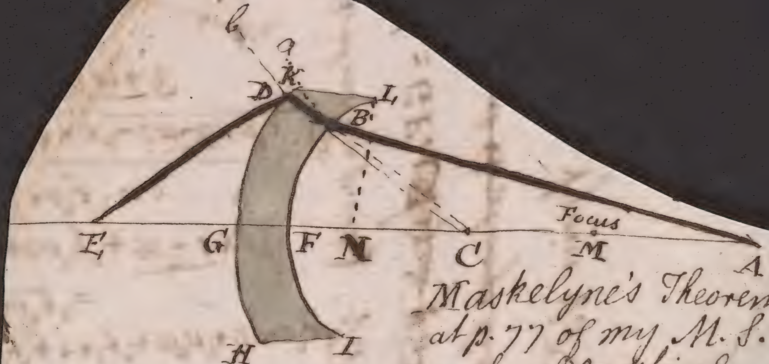
TROPICS, τρέπω verto.

ZODIAC, ζῶον Animal, because it's 12 signs are represented by Animals.

Projectiles proved not to describe Parabolas.

ZONES, ζώνη Cingulum.

(*) ECLIPTIC, ἐκλείπειν Deficere, because in & about it happen all the Defects & Eclipses both of the sun and Moon.



Maskelyne's Theorem
at p. 77 of my M.S.
See philosophical
Transactions 1763. p No.
31. p. 173.

Put $GA = Q$ $\quad LN = Y$
$CB = R$
$CD = r$
$EM = F$
$FB = Y$

... ~~+~~ $m = 1 \mp 2.$

$\ldots y^2 + 2a^2y^2 + m^2a^4 + 2ma^2x^2$

$\ldots a^2y^2 =$

$\ldots + 2a^2y^2 + \overline{m^2-1} \times a^4$

$\ldots 2 \times a^2x^2 = 0$

$\ldots 2 \times a^4 - \overline{2m-2} \times a^2x^2 \,\rceil^{\frac{1}{2}}$

$\ldots 2m+2$

...drithmetica p. 143) $\sqrt{a^2-y^2} = BF$:

... $= GE$, ~~Again $\sqrt{a^2-y^2} = BF$~~

~~...d G always bisects DF~~ and

Again $\sqrt{a^2-y^2} = BF$:

In the letter at the end of Vol. 3 of Spect. de la Nat. "There are a competent number of proofs, whose tendency is to shew, that the Physical why the life of ~~men~~ men before the flood was much longer than ours, is, because the sun not then leaving the Equator, it necessarily followed, that the temperature of the air must be uniform, and the fruitfulness of the earth never interrupted. The sun ruled the year as now it does, and fixed both the progress and limits of it, by passing from one constellation to another. But neither the place of its rising & setting, nor the length of days in any time ever varied". Again "We have, in the said letter, collected a good number of Scripture and prophane history, and from the vestiges still subsisting and scattered from one end of the earth to the other; whereby it appears, that there were before the flood no rainbows, nor any winds or great rains and meteors; but that a perpetual spring and universal serenity reigned all over the earth, except under the Equator, where the course of the air dilated or contracted by the alteration of the day and night, must needs have brought from either pole a continued collection of vapours, as it still happens under the Tropics, for several weeks together. After the flood, another heaven (2 Pet. III. 7.); a new disposition of the stars with regard to us, occasioned by the inclination of the axis of the earth; a vicissitude of seasons; rains new as the rainbow, which is but the consequence & necessary effect of them; troublesome meteors; inconstant winds; earthquakes, storms, inundations; perpetual crosses in all the Operations of agriculture, frequent diseases; fertility diminished; man's life much shorten'd than before".
Vol. I. p. 8 ... & 73, 74. of the History of the Heavens Translated from the French of the Abbé PLUCHE. Author of the Spectacle de la Nature; or Nature Displayed. By J. B. DE FREVAL, Esq. 2 Edn 2 Vols. 8vo 1741.

Thales planted a willow of five pounds weight in a lixivial earth of 200 pounds weight. That willow in 5 years time came to weight 164 pounds exclusive of the leaves fallen each year, and the earth had lost nothing of its weight. Peas, Beans, & other corns will open, blossom and fructify without the Assistance of any earth, by wrapping them up in a small quantity of wool, and by letting them shoot forth their fibers through a little grate to fetch all their nourishment from the water in a bowl placed directly under them. Do Vol. II. p. 119. & 120.

Copper Utensils or those made of brass, which is the same metal incorporated with a fossil substance well known by the name of lapis calaminaris, or calamine stone, is very pernicious to Health; for the blue mould which grows upon them, by long standing, fries out to a much greater degree when filled with any substance and made hot over a fire; which mould is a strong verdigrease & very poysonous, by which some have lost their lives. Universal Mag. Vol. XVI p. 73 for February 1755.

A Ladder being placed obliquely 32 feet high, a square pane of glass was fixed to each round; the ~~first~~ Dew first appeared upon the under surface of the lowest pane, then upon its upper surface, next upon the under surface of the next higher pane, and so on in successive order. Cloths was put instead of the panes and weighed, was also found to succeed in the like order. Again the Dew sticking to some bodies and not others, if a metalline cup (to which it does not stick) be set a whole night in the Air, there never will be found any the least dew within the cup. Therefore the Dew Ascends out from the earth in the form of Vapour, but never descends. Univl. Magaz. V. XVI. p. 76.

To preserve the parabolic curve described by projectiles practical gunners almost unanimously agree, that from the great disproportion of the density of the bullets and of the air there is little or no resistance from the air and also that every shot flies in a straight line to a certain distance from the piece, which they call, "the extent of the Point blank shot". But Gravity is never suspended therefore this rather makes it worse than mends it, besides Mr Robins experimentally proves that the resistance to a cannot shot amounts to more than twenty times the weight of the shot. Ex. gr. a musket-ball 3/4 of an inch diameter, fired with 1/2 its weight of powder, from a piece of 45 inches long, moves with a Velocity of near 1700 feet in a second. Now by common parabolic theory, its horizontal range at 45 degrees of elevation, =

7)

A Question. By Mr. G. Witchell, Teacher of the Mathematics, at the Front House in White Fryers Gate, Fleet street.

(From Martin's or the General Mag. Jan. 1764. p. 34. and Solved by him March. 1764. p. 139.)

See p. 144. for measuring the degrees in a Spheroid corresponding to those in a Sphere.

Suppose a Circle to be described upon the transverse Axis of a given Ellipsis, (as a Diameter) and that a Right-line be drawn, through two given Points in the Circumference of the Circle, to cut the Ellipsis; it is required to determine the Lengths of those two Segments of the right-Line, which are intercepted between the Peripheries of the Circle and Ellipsis.

CONSTRUCTION.

Let BC (fig. 17.) be the trans. diam. of the given ellipsis, and BEDC its circumscribing circle; thro' D, E, the two given Points, draw the line DE, producing it (if necessary) till it meets CB (produced also) in A; at any point (C) of the line AC, erect the perpendicular CH, meeting the right line, AH in H; in CH, produced, take Ch to CH, in the ratio of the greater axis of the given ellipsis, to the lesser, and join h, A, then from g and f, the intersections of the right line Ah, with the Circle BEDC draw gI, and fK, perpendicular to AC, intersecting AH in G and F, then shall EG, and FD, be the required Segments.

Oil & Sulphur the Cause of all Vegetable colours.

DEMONSTRATION.

The lines gI, fK, and hC, being parallel to each other, it follows (from similar triangles) that the ratio of gI to GI, and of fK to FK, will be the same as the ratio of hC to HC; that is (by construction) as the ratio of the greater axis of the given ellipsis to the lesser, therefore (by conics) the points F and G, will be in the periphery of the given ellipsis BGFC, Q. E. D.

Lunar Eclipses retard the moon in her periodical motion.

CALCULATION.

The Angle DLC and ELB, being given (by the question) we shall have the angle $DAL = \frac{DLC - ELB}{2}$(*); therefore in the triangle ADL, there is given all the angles, together with the Side DL, from which AL becomes known; but the tangent of the Angle FAK, is to the tangent of the angle fAK, as FK to fK, that is, as the lesser axis of the given ellipsis is to the greater; whence in the triangle AfL there is given the angle fAL, together with the sides AL, Lf, by which the angle AfL will be found; but the sum of the angles fAL, AfL, is equal to the angle fLK, and the tangent of the angle fLK, will be to the Tangent of the angle FLK as fK to FK, that is, as the greater axis of the given Ellipsis, is to the lesser, therefore the angle FLK will be known, from which, taking the given angle DLC, there will remain the angle FLD. but fL is to FL, as the secant of the angle fLK, is to the secant of the angle FLK (or, which amounts to the same, reciprocally as their co-sines) therefore FL will become known; lastly, in the triangle FLD, there is given, the two sides FL, DL, with the included angle FLD; whence FD will be easily found: and by a similar process, EG may be determined.

(*) This appears from lines being drawn from B to D, and from E to C: for then $DEC = \frac{1}{2}DLC$, & $ECA = \frac{1}{2}ELB$ but $DEC = DAL + ECA$ ∴ $DAL = DEC - ECA = \frac{DLC}{2} - \frac{ELB}{2}$.

Thence arises an Error in the Tables.

ALGEBRAIC SOLUTION.

Let ABCD (fig. 18.) represent the given Ellipsis, and M, N, the two given points in the circumscribing circle, draw the ordinates MK, LI, and NP, then will PH, HN, and HK, HM, be given. To find the segments ML, and NE, put OA = OC = t, OB = OD = c, HC = a, HK = b, KM = d, CI = x. Then, per property of the ellipsis, $IL = \frac{c}{t}\sqrt{2tx - x^2}$, and per similar triangles, as $HK = b : KM = d :: HI = a - x : IL = \frac{c}{t}\sqrt{2tx - x^2}$, therefore $td \times \overline{a - x} = bc\sqrt{2tx - x^2}$, from which equation the value of x may be easily found, and in consequence of that the segment ML may be found also: and according to the same method of reasoning, the other Segment NE may be found. Contind. on p. 9.

Water, exhalations, &c. & not Air, is the cause of Refraction, which proves no solid Orbits in the expanse

The argument of rays passing thro' a vacuum is false.

Pure Air neither reflects nor refracts light, but water does both, thence the refraction of the

miles. But in practice it is short of half a mile. the resistance of the Air to this bullet, when it first issues from the piece, amounts to 120 times its gravity. Again an iron bullet of 24.lb made with a full charge of powder, has a velocity of 1650 feet in a second; and the amplitude, at 45°, according to Theory, = 16 miles; but, by experiment it was short of 3 miles. The same is in much less velocities for a bullet 3/4 of an inch diam. fired at different elevations with a velocity of 400 feet p 1" did not at all answer common theory. Likewise the elevations under 45 degrees are greater than those above, which, by theory, are equal. And the vertex of the curve they describe is much nearer the point where they strike the ground, than to that from whence they were first discharged. Also they were frequently driven to the right or left of the point directed to, by the action of some other force: the error was always uncertain & bore no ratio to the distance. Universal Magaz. Vol XVII. p. 104. for September 1755.

"It is generally agreed among the chymists, that all colours arise from sulphurs, and that they differ, according to the different admixture of salts with these sulphurs. the flowers of all plants abound in an essential oil or sulphur, to which their colours may be rationally owing. Though this oil should be the same substance in all, yet their varieties of colours may be accounted for from it; since, that one and the same oil (viz. the essential oil of thyme) may be turned to all the colours that we find in the different flowers of plants. The infusions of fowers, and of other parts of plants, become red on being mixed with acids, and green on being mixed with alkali's. from the sulphureousness of the vegetable. See more at large Universal Mag. Vol XVII. p. 22. for July, 1755.

" The reflexion of the light from the earth greatly rarifies the medium between her and the moon in conjunction, but in eclipses of the moon, part of this space is made denser, so that the inequality of pressure is not so great upon the moon as at other times; in consequence of which the motion of the moon must be retarded by eclipses, and hence it is, that ~~the~~ calculations from modern Tables will not agree with the observation of ancient eclipses; ~~and likewise~~ nor ancient Tables ~~will not~~ answer for the present time; neither will any tables continue true for many ages, because, from these eclipses, we are continually gaining time of the moon, or to express it more accurately, the Solar time hereby is continually gaining upon the Lunar time. No other ~~satellite~~ setalite can thus be apparently discerned, because they very rarely miss passing thro' the shadow of their primary, and thereby is included & reckoned into their periods, tho' unknown to the astronomical Observor. — Eclipses of the sun seldom or at most reach but a very small spot upon the earth cannot so sensibly affect her in this respect, if at all sensible, so that it is peculiar to the moon alone, whose motions are the most irregular of all the Celestial bodies. Mr Jones.

The Astronomers finding that the times of lunar eclipses happened later in some ages ago than they ought by the present astronomical tables, are led to think the moon is continually accelerated, & some have gone so far as to compose tables for that supposed accelaration, to be added both for ~~former ages~~ past and future ages, of which, the latter is false, because it is a retardation, which they are not aware of.

Tycho Brahe argued from Refraction against the solid orbs of Aristotle: for if any such orbs had existed, the rays of the heavenly Bodies could not have passed thro' them to our sight but under several Refractions; which is contrary to observation.

But this argument has of late been carried much farther; even to prove that these rays are transmitted to us through a vaccum, or nearly such, because they suffer no refraction till they come very near the Earth's surface. which conclusion is much too hasty; it being here taken for granted, without any proof, that the Air, strictly understood, is the refracting medium; whereas the pure air is perfectly pellucid, and by all that appears does neither reflect light (*) nor refract it. Water will do both; and the air near the

(*) Air does not reflect light, because a space exhausted of air looks as bright or brighter than filled with air; whereas it ~~my~~ ought to look dark.

Page 7. continued.

Atmosphere. V. p. 54 & 56.

Corollary 1. (from the 1st. Solution)

Application to Solar Elipses.

Hence if D, represent a given place on the surface of the earth, considered as a sphere, and the right line AH be supposed to be the axis of the moon's shadow (in a solar eclipse) falling the place D in a given direction, the solution of this problem, affords a method of determining the position of the place F, on the surface of a Spheroid (whose section is the ellipsis BGFC,) where the eclipse will be central at the same instant of time: and by the help of this problem, I constructed the map of the ensuing eclipse, (on Apr. 1. 1764) which I lately published.

Why least at the Equator, & the great dews there.

Exhalations have a determinate height, but pure air may reach to the fixed Stars. Refraction greatest from Hills.

Corollary 2. (from D°.)

And to the Eclipses of Jupiter's satellites. See p. 13A.

If the body of any primary planet, should deviated so far from a sphere, as to affect the form of his shadow, the curve of the section of the shadow (made by a plane perpendicular to its axis) at a small distance from the primary, will not be sensibly different from an ellipsis, and, by the means of this problem, we may determine the duration of an eclipse of a satellite, passing through such a section of the shadow. —— That excellent astronomer, Dr. Bevis, was the first person who suspected that some irregularities, observed in the eclipses of Jupiter's satellites, resulted from this cause; this he mentioned to me, in a conversation upon that subject, about three years ago; and sometime after, I presented to him a paper, containing a general investigation of the nature of the curve, which arises from the section of such a shadow. This is the paper mentioned by M. de la Lande; vide Connoissance des mouvemens célestes, pour l'annee 1765, p. 177.

Principles of H's Philosophy.

1st. All actions in Nature are Mechanical see the margin p. 97.

2d. The Universe is a Plenum.

3rd This Plenum is the three Ætherial fluids,

Fire, what.
Light, what.
and
Air, what.

Ratio of the ⊖'s Diameters, & that it ought to be a Spheroid from Solar Eclipses.

The ratio of the earth's diameters has been found to be as 178 to 179; but later observations make the figure of the earth to approach nearer to a sphere, and that the ratio of its diameters is nearly as 215 to 216 which best corresponded to the observations of the solar eclipse on April 1st 1764. from which observations as well as the calculations, it appears that the deviation of the figure of the earth from that of a sphere, will produce a very considerable effect, with respect to the passage of the shadow, no less (in this example) than thirty-two geographical miles, by which means, if the calculation had be made in the usual manner, the limit, instead of passing over Rochester, would have scarce reached Canterbury, and the eclipse would not have been annual in any part of Essex, Suffolk, or Norfolk; it is therefore absolutely necessary to have regard to the spheroidal figure of the earth in the calculation of solar eclipses, and, as I (G. Witchell) do not know that any author has given sufficient precepts for that purpose, I intend to treat particularly upon it, in a treatise, which I am now publishing by subscription.

In 2d. Edit. of Chamber's Dict. under Earth, the last and best ratio is as 1 to 0,9953A67 or 230 to 228,92974, which is very nearly as 216 to 215, being as 1 to 0,9953708. In Mayer's Tables p. LXXV. it is taken as 1 to 0,995886. or as 230 : 229,0032 or as 216 : 215,063359

4th. Fire, light & air can't be supported or increased, but from one another.

5th. This fluid is the cause of all motion in Nature.

Dimensions of the ⊖. see p. 136.

By many observations given under the word EARTH in the complete Dict.y of Arts & Sciences: the polar diameter is deduced from a long process = 7863,2 Miles, & the Equatorial = $\frac{1}{92}$ × 7863,2 + 7863,2 = 86,8 + 7863,2 = 7950 miles. And 7863,2 : 215 :: 7950 : 217,386; ∴ greater in Ratio than Witchels 215 : 216. * Also 7863,2 : 178 :: 7950 : 179,965 fere; ∴ greater than 178 : 179, the Ratio he rejects; being nearly as 89 to 90.

the earth is always loaded with more or less, as we find in rarifying the medium by an air-pump, on which occasion it never fails to let fall a cloud of vapours. It is impossible that light should enter ~~the~~ Air thus impregnated without being refracted: and that the refraction of the Atmosphere is thus to be accounted for is plain from hence, that refraction is always greatest in hazy weather, when the air contains most water in it, as the French Academy observed long ago. This will give a reason why refraction is so much less near the Equator: for the air being rarer with Heat in that Climate, will not sustain such a body of water as with us, but lets it fall as soon as the cold of the evening comes, whence their excessive Dews. Again, the Air in the Polar reigons being more dense, will sustain a much greater quantity, so that their Atmosphere after the frost of a whole winter will be almost converted into a rarer sort of Ice, whence the excessive Refraction in those Parts.

We are to assert then, that water and terrestrial Exhalations have a determinate height in the Atmosphere; but as for the Element of Air, for any thing that refraction proves to the contrary, it may be extended to the Moon, or the fixed stars themselves. J--nes

Upon the summit of an high mountain, the Atmosphere is rarer than at the bottom, therefore the refraction from the top of an Hill is greater than the Horizontal refraction, where the density of the Atmosphere, between the object and the observer, is nearly the same.

The Principles we are to establish are few and plain. If they agree perfectly with what we observe in Nature, they must be true and worthy of reception: if they should be contradicted by common appearances that are before us, we have mistaken our Evidence, and they ought to be rejected to make way for some better System, if time and experience should discover any such to the world; but I am fully persuaded we are safe enough. The Principles are these,

First, That all the actions of nature are & must be mechanical; in other words, that the System of nature created, disposed, & set in to motion by the Finger of God, acts as a machine does, by one portion of matter pressing upon another, with which it is in contact: for if in any part you interrupt the contact of a machine you necessarily destroy its motion. That therefore

Secondly, The System of the World is a plenum, or Space filled with matter, so that evry part throughout the whole contains matter resting upon other matter, without any such void as may destroy its Mechanical continuity.

Thirdly, That this plenum is constituted or composed of the fluid Etherial matter of the heavens, the whole of which is one and the same substance, but capable of three different conditions, under which it is observed to subsist: which conditions are understood by the names of Fire, Light and Air. These are so many gradations of the etherial fluid. Fire is this matter in most refined state, subsisting in the smallest ~~state~~ and most subtile parts to which it is capable of being reduced. Light is the immediate state of this matter between fire and air. it is the emanation of fire, disseminated throughout the world; not always visible, but rendred so by some certain motions impressed upon it. Air is the etherial fluid in its grossest state; and as fire is air comminuted & broken into its smallest parts, so air is fire or light congealed again into Masses or grains.

Fourthly, That this fluid in any one of its conditions can receive no support or increase but from the same fluid in another of its conditions; so that if the density of ~~the~~ Air be increased, it is owing to the adherence of congealation of more fire into that state; if light be increased there must either be a fresh supply from a focus of fire, or air must be reduced by motion and friction into that state. If fire is quickened & strengthened it must be from the influx of air, for light cannot sustain its action.

Fifthly and lastly, That this fluid, subsisting in the conditions above mentioned, is the cause of all motion in the natural creation. other matter, as Water, Earth, and the various sorts of fluids and solids being wholly passive

an

Of the Solid of greatest Attraction.

General Rule how the Agents or fluids Act, and Motion thence ensues.

A Physico-Mathematic PROBLEM.

Supposing the Law of Attraction to be in the inverse Ratio of the Square of the Distance, to find the Nature of the Solid of the greatest Attraction.

SOLUTION, by Mr. ST. JAMES. the Proposer. in General Mag. Jan.y 1764.

It is plain that in the first place, that the Solid which attracts the given point A with the greatest possible Force, of all Solids under the same Quantity of Matter, must be a Solid of Rotation, since there can be no reason, why the Matter should be distributed more on one side than on others. — To find the Nature of the Curve which forms this Solid by a Rotation about its axis, let there be taken four equidistant and infinitely near Ordinates, and let the Lines MN, (fig. 19.) NO, Om be three infinitely small Sides of the Curve, whose Points M and m are supposed to be fixed, and the Points N and O variable. Call the Lines AP, AQ; AR, Ap; x, x'; x'', x''' the Lines PM, NQ, &c. y, y', &c. the Lines AM, AN, &c. z, z', &c.

Descartes's Character & Principles of Philosophy.

First, by the Nature of the Problem, we have, $yy\dot{x}+y'y'\dot{x}+y''y''\dot{x}$ = a constant Magnitude; whence, after having taken the Differences, and observing that only y' and y'' are variable, we get $y'\dot{y}' = y''\dot{y}''$. — Now we shall find, by well known Methods, that the Attraction of the Solid formed by the Rotation of MNmpP about Pp is $\overline{1-\frac{x}{z}}\times\dot{x}+\overline{1-\frac{x'}{z'}}\times\dot{x}+\overline{1-\frac{x''}{z''}}\times\dot{x}$, which should be a Maximum: Therefore, taking the Difference, and observing that only z' and z'' are variable, and making it $=0$, we get $\frac{x'\dot{z}'}{z'\times\overline{z'-\dot{z}'}} = \frac{x''\dot{z}''}{z''\times\overline{z''+\dot{z}''}}$; but the Right angled Triangles ANQ, AOR, as the Points Q and R are fixed, give $y'\dot{y}'=z'\dot{z}'$ and $y''\dot{y}''=z''\dot{z}''$: Therefore $\frac{x'y'\dot{y}'}{z'z'\times\overline{z'-\dot{z}'}} = \frac{x''y''\dot{y}''}{z''z''\times\overline{z''+\dot{z}''}}$. And since $y'\dot{y}'=y''\dot{y}''$, we shall have $\frac{x'}{z'z'\times\overline{z-\dot{z}'}} = \frac{x''}{z''z''\times\overline{z''+\dot{z}''}}$ = a constant Magnitude $\frac{1}{gg}$; therefore we shall have $z^3=ggx$ for the Equation of the Curve required.

An easier SOLUTION.

The Problem might be solved another far more simple Way, by taking the Attraction of any one point of the Surface of the Solid; which attraction is $\frac{x}{z^3}$, and making it equal to a constant Magnitude $\frac{1}{gg}$, we shall have $z^3=ggx$, for the Equation of the required Curve, as before: For 'tis manifest, that if the attraction were less on any ~~point~~ Place of the Surface than another, that Point might be placed out of the Solid, so as that it would attract more, and the Solid would be no longer that of the greatest Attraction, contrary to the Hypothesis.

Continued on p. 13.

and subject to no change but what is induced by a prior change in the Agent. The general rule by which it acts is one only, to which all particular cases may be reduced; and it is this; that the grosser and heavier part ~~parts~~ of the fluid always presses toward the lighter, and rarer, endeavouring to preserve the Equilibrium established in nature; whence it will follow, that whatever bodies ~~the~~ lie in its way will be moved, carried (or at least affected) by it according to their different capacities, and that an inequality of pressure must always produce motion, in a degree proportioned to the inequality, and in a direction toward the weakened or interrupted part of the fluid. It will follow also, that some parts of this fluid will pass the pores of solid bodies, and act upon their whole content, while others too gross to enter the pores, will press upon the surface.

These are the Principles by which we account for the various effects that are daily arising in the œconomy of the world, as far at least as those effects lie open to our observation. They are so plain and easy, and in the main so far confirm'd by common experience, that one would almost be tempted to think they could find no adversaries; but Mankind, who never yet agreed in any Science, have differed very much in that of natural Philosophy. The works of God, like that other volumn of his word, are capable of many interpretations; and every Age almost has had its fashionable System of Physics.

In the last age Descartes was the Philosopher: a man of a subtile and inquisitive disposition, and of no ordinary skill in the mathematical knowledge. His Principles were these; That the Elements of the æther was created in solid parts of a cubic figure, among which a motion, being introduced, their corners would be rubbed off by the attrition, and supply a finer sort of matter, which he called the <u>materia primi elementi</u>, as being of much more subtilty and force than the (~~[illegible]~~
~~[illegible]~~)

A PROBLEM, with its SOLUTION, concerning the solid of greatest attraction. By Mr. T. Allen, of Spalding Lincolnshire. (General Mag. March 1764. p. 136.)

To find the area of the curve, which, revolving about its axis, shall generate the solid of greatest attraction, supposing its force to act on a corpuscle placed on its surface. also the content of the said Solid, and the ratio of its attraction to that of a sphere of the same quantity of homogeneous matter, taking the axis of the solid = the invariable quantity g. (See the Prob. on p. 11.)

SOLUTION.

Area of the Solid of greatest Attraction.

Let AMBC (fig. 20) represent the required solid. Put $AB=g$, $AP=x$, $AM=z$, and let $c=3.1416$.

Then for the area of the curve AMB. From the given equation $z^3=g^2x$, we have $x=\frac{z^3}{g^2}$, and therefore, $\frac{1}{g^2}\times\sqrt{g^4-z^4}\times z=PM$. Moreover, $\dot{x}=\frac{3z^2\dot{z}}{g^2}$, and consequently $\frac{3}{g^4}\sqrt{g^4-z^4}\times z^3\dot{z}$ is the fluxion of the area, whose corrected fluent is $\frac{1}{2g^4}\times\overline{g^6-\overline{g^4-z^4}|^{\frac{3}{2}}}$, which when $z=g$, becomes $\frac{1}{2}g^2$ the area of the curve AMB, required.

For the Content of the required solid.

Content.

From what is given above, we have $\overline{PM}^2=\frac{1}{g^4}\times \overline{g^4-z^4}\times z^2$; therefore the fluxion of the solid will be $\frac{3c}{g^6}\times \overline{g^4z^4\dot{z}-z^8\dot{z}}$, whose fluent is $\frac{3c}{g^6}\times\overline{\frac{g^4z^5}{5}-\frac{z^9}{9}}$, which, when $z=g$, becomes $\frac{4g^3c}{15}$, for the content of the solid AMBC.

To find the force of attraction, &c.

Compared with a Sphere.

The force of attraction of the circle MPC will be, as $1-\frac{x^{\frac{2}{3}}}{g^{\frac{2}{3}}}$ by the equation of the Curve, and therefore $\dot{x}-\frac{x^{\frac{2}{3}}\dot{x}}{g^{\frac{2}{3}}}$ as the fluxion of the force of the solid, whose fluent is $x-\frac{3x^{\frac{5}{3}}}{5g^{\frac{2}{3}}}$, which, when $x=g$, becomes $\frac{2g}{5}$ for the attract of the solid.

Let $a=$ the diameter of the sphere ANDE equal to the solid AMBC, then will the fluxion of the force of the sphere be as $\dot{x}-\frac{x\dot{x}}{\sqrt{ax}}$, and the fluent $x-\frac{2x^{3/2}}{3\sqrt{a}}$, and the force of the whole sphere, as $\frac{1}{3}a$. Moreover, the content of the sphere is $\frac{ca^3}{6}$. Therefore $\frac{4g^3c}{15}=\frac{ca^3}{6}$, where $a=g\times\overline{1.6}|^{\frac{1}{3}}$. Whence, the force of the solid to that of the sphere, is as $\frac{2g}{5}$ to $\frac{a}{3}$, or as $\frac{2g}{5}$ to $\frac{g}{3}\times\overline{1.6}|^{\frac{1}{3}}$, that is, as 4000 to 3899 nearly.

Magnetism will not prove Gravity & Attrctn INHERENT qualiti: but affords strong presumsion for the reverse.

The most indefatigable pains & application have been made on the attractions and repulsions of ~~the~~ load-stones, both with iron and with each other; but it never could be found that they followed any regular proportion in the increase of attraction in their approach to, or descrease of attraction in their recess from, one another. — only that the force of the magnetic virtue did increase and decrease with the distance from the stone; but not exactly as the distances, nor as the square or cube of the distances, either directly or reciprocally: — nor in any proportion reducible to numbers. Dr. Desaguliers's expert. philos. Vol. I. p. 40. 2d Edit. 1763.

Light, will give, change, or take away Magnetism.

Colour, what.

Syderial Time its Quantity.

Brass without Weight

Those who consider Gravity as a quality inherent in Matter, call this quality an attraction; and to illustrated their meaning, as well as to prove that such a quality as they speak of does actually reside in bodies, they refer us to the attraction of the Loadstone. Now the question is this; whether Gravity be the effect of some material ~~agent, such as they suppose~~ Agent, or whether it is owing to some immaterial cause, such as they suppose their attraction to be? If Gravity be owing to the latter of these, then the attraction of the Magnet can afford no proof nor illustration of such a thing, unless that also be occasioned by an immaterial virtue: but that it certainly is not; for the following reasons. first, because the Loadstone may be deprived of its attractive power, which it could not be if that power were inherent in the particles of which it is composed. Gold dust will have exactly the same weight as the same quantity of Gold in a solid lump, and will be attracted (as we speak) toward the earth with the same force. but this does not hold in the Loadstone; the power of which loses its effect, and if a large stone be divided into several small pieces, the sum of the attraction in those pieces does greatly exceed the attraction of the original & intire mass from whence they were broken. Secondly; if the attraction of Magnetism were essential to any matter, than it could not be given to any body not naturally invested with it; the contrary to which is true from Experience; for a Loadstone will give it to Iron, & one piece of Iron will give it to another. but this is not the case with Gravity. Thirdly, Gravity as a quality, cannot be illustrated by Magnetism as a quality, because Magnetism is occasioned by the action of other matter on the magnetical body. For how does it happen that fire will give or change or take away the effect, unless that all-penetrating element be the natural of magnetism? Lightning falling accidentally on instruments of Iron, has made them strongly magnetical, and they have retained this power for ~~many~~ several years. It has also been known, more than once, to change the direction of magnetic needles on shipboard, so that Pilots not aware of the accident have steered a course contrary to what they designed. The Electrical fire will also make a small needle magnetical, as Mr Franklin found by trial. a rod of Iron heated in the fire & cooled in the directions of the Poles will become magnetical, & either attract or repel the needle according to the position you give it in cooling it. then again, iron already magnetical may be deprived of its power by the action of fire; just as a body by burning will be deprived of its colour and turned black; tho' the same fire that takes away colour, will also give it if applied properly; for Iron in heating will receive all the colours of the prism as the degree of fire changes in it. Magnetism therefore is no more an immaterial quality in a body than colour is. colour is nothing but the effect of fire or light acting on the body; and the same element that performs this, is well able to produce all the phenomena of magnetism. Many other Symptoms might be added to prove that what we call attraction in the loadstone is only an effect of some material fluid. and if magnetism be owing to the action of matter, it is strongly to be presumed that Gravity is owing to the same. magnetism is so far from tempting us to rest in gravity as a quality, that it rather encourages us to search after its cause. W. J.

The diurnal mean motion of the earth is $\frac{360^\circ \times 86400'' \text{ each } 4'''}{365^D\ 5^H\ 48^m\ 57^s} = ,98565$ fere, which converted into time gives $3^m\ 56^s\ 33'''\ 21^{iv}$ for the time of each fixed star transiting the Meridian ~~sooner~~ sooner than on the preceding night. V. De La Caille's Astro. b. II. Chap. I. Art. 8. from page 147 to 152.

2. Kings XXV. 16 The brass of all these vessels was WITHOUT WEIGHT.

An Algebraic Question

By Stamfordiensis. (General Mag. April 1764. p. 190.)

Mr. Landen, in his Residual Analysis, has, by dividing $v^{\frac{m}{r}} - w^{\frac{m}{r}}$ by $v-w$, and a few other theorems, been enabled to solve the most difficult problems in the mathematics, upon the common principles of algebra, without fluxions; now this quotient

$$\frac{v^{\frac{m}{r}} - w^{\frac{m}{r}}}{v-w} = v^{\frac{m}{r}-1} \times \frac{1 + \frac{w}{v} + \overline{\frac{w}{v}}\big|^2 + \overline{\frac{w}{v}}\big|^3 (m)}{1 + \overline{\frac{w}{v}}\big|^{\frac{m}{r}} + \overline{\frac{w}{v}}\big|^{\frac{2m}{r}} + \overline{\frac{w}{v}}\big|^{\frac{3m}{r}} (r)}$$

m and r being positive integers, The investigation is required?

Answered, by Mr. T. Allen of Spalding.

(General Mag. June, 1764. p. 292.)

When m is a positive integer, $\frac{v^m - w^m}{v-w}$ will be universally $= v^{m-1} + v^{m-2}w + v^{m-3}w^2 (m)$ and $\frac{a^r - b^r}{a-b} = a^{r-1} + a^{r-2}b + a^{r-3}b^2 (r)$. (Both found by common division) Now, if in the second Equation we write $v^{\frac{m}{r}}$ and $w^{\frac{m}{r}}$ instead of a and b respectively, there will arise $\frac{v^m - w^m}{v^{\frac{m}{r}} - v^{\frac{m}{r}}} = v^{m-\frac{m}{r}} + v^{m-\frac{2m}{r}} w^{\frac{m}{r}} + v^{m-\frac{3m}{r}} w^{\frac{2m}{r}} (r)$; by which, if the first equation be divided, we obtain $\frac{v^{\frac{m}{r}} - w^{\frac{m}{r}}}{v-w} = \frac{v^{m-1} + v^{m-2}w + v^{m-3}w^2 (m)}{v^{m-\frac{m}{r}} + v^{m-\frac{2m}{r}} w^{\frac{m}{r}} + v^{m-\frac{3m}{r}} w^{\frac{2m}{r}} (r)}$. Now, dividing the right hand side of the last equation by $v^{\frac{m}{r}-1}$, it becomes $\frac{v^{m-1} + v^{m-2}w + v^{m-3}w^2 (m)}{v^{m-1} + v^{m-\frac{m}{r}-1} w^{\frac{m}{r}} + v^{m-\frac{2m}{r}-1} w^{\frac{2m}{r}} (r)} =$ (by Dividing numerator and denominator by v^{m-1}) $\frac{1 + \frac{w}{v} + \overline{\frac{w}{v}}\big|^2 + \overline{\frac{w}{v}}\big|^3 (m)}{1 + \overline{\frac{w}{v}}\big|^{\frac{m}{r}} + \overline{\frac{w}{v}}\big|^{\frac{2m}{r}} + \overline{\frac{w}{v}}\big|^{\frac{3m}{r}} (r)}$: Therefore $\frac{v^{\frac{m}{r}} - w^{\frac{m}{r}}}{v-w} =$

$$v^{\frac{m}{r}-1} \times \frac{1 + \frac{w}{v} + \overline{\frac{w}{v}}\big|^2 + \overline{\frac{w}{v}}\big|^3 (m)}{1 + \overline{\frac{w}{v}}\big|^{\frac{m}{r}} + \overline{\frac{w}{v}}\big|^{\frac{2m}{r}} + \overline{\frac{w}{v}}\big|^{\frac{3m}{r}} (r)}$$

the theorem proposed to be investigated.

Æther dispers'd all over the Universe.
Consequence of one Body placed therein.
D^o. of two Bodies.

Increase of a Grain of Wheat

An humble and submissive conclusion of a Writer, from Drusius.

Motion of the Earth asserted by Job, in VII. 1.

An Hypothesis concerning GRAVITY; by M. Cramer, Professor of Mathematics at Geneva. (from the London Magaz. May 1734. p. 256.)

1. Space is filled with a very subtle and very rare Fluid; insomuch, that there is no sensible point in the whole Extent of the Universe, from which an infinite Number of Rays of this fluid do not proceed, in all possible directions. which is Æther.

2. Let us suppose there were but one body in the World, What would be the Consequence? This body would be so pressed on all Sides, that its Parts would tend all equally towards their common Center.

3. Let us suppose, that, instead of one Body, there were two; for Example, the Sun and the Earth. I say that these two Bodies, whatever were their distance, would endeavour to come together. Thus it is proved. The Pressure of the Æther would not be more uniform, but it would be less, in the supposed space between the Sun and the Earth. For the Æther, which came from the side where the Sun is, could not press the Part of the Earth, which looked towards the Sun, without having traversed its Body, and reciprocally. Now, among these Particles of Æther, which thus traverse the Body of the Sun, and that of the Earth, many of them must be reflected in meeting with the Solid Parts of these Bodies, and some even stopped in the Body they should traverse; while others, find proper Pores to let them pass thro, lose however great part of their motion propter affrictum. Consequently, the Pressure of the Æther on the Sun will be less on the Side of the Earth; and reciprocally the Pressure of the Æther on the Earth will be less on the Side of the Sun. The Equilibrium thus lost, it is evident that these two supposed bodies, press'd from without, and not inter se, will tend the one towards the other, and even come together, unless prevented by some other Cause.

"A Gentleman was pleased to declare, October 20, 1757, that from one single Grain of Wheat sown in his Garden, he had returned 5600 Grains, the largest Number produced I ever heard of from any Kind of Grain whatever." Compare, John XII. 24. Dr R's Xn P. Vol. II. p. 300. a Note there.

"My friendly Readers, I hope, will suffer me to close this Work, with these excellent Lines of the learned Drusius, who, when he was about to Publish to the World some Points of Divinity, that he conceived, might not altogether be agreeable to the reigning Taste of the then present Age, thus addressed ~~himself~~ the Public: — Scripsi hoc Animo juvandi non lædendi. Si læsi quem piam, jam me pænitet. Si offendi pias Aures; monitus, lubenter mutabo. Si erravi uspiam, monstretur mihi error non ero pertinax. Drus.

And which, for the sake of my unlearned Readers, I english thus: —
These Volumnes I publish to the World, with a Sincere desire to assist, not offend any one. If what I have written, gives offence to any good and pious Christian, I am heartily sorry. If erroneous Opinions any where start up, and displease persons well affected to the Christian Cause, being made sensible of my Mistakes, I shall readily retract, and not obstinately persist in any known Error. Dr R's Xn P. Vol. II. p. 332 & 333, or last.

— Opere in longo fas est obrepere somnum. Hor. de Art. Poet. 360.

Job most beautifully describes human Life as a State of perpetual Warfare, and much grander than our common Translation, in VII. 1. which should be — Verily an Army (of Enemies) is against fallen and miserable Man on this Globe [which is + continually running its Course] and as the Days of a Warrior, so are his Days. Aboab on Xianity Preface p. 13

+ ארוץ Aretz, I will run. רץ Retz, a Globe.

Rec.t for Lacque.

To make a very good lacque, or varnish.

Take a very clear lye of pot-ash, or tartar, add to it a very small quantity of a solution of allum; put the lye into a very large glass vessel; take some powdered cochineal, which must be carefully sewed into a linen bag, which stir about in the lye till no colour remains in it. That which is first extracted is best, and may be kept in a separate glass. When the colour is all extracted, take some very clean ~~allum~~ alum-water, which pour on the lye, till the whole is curdled; it must then be filtered, and the varnish purified.

General Mag. March. p. 134. (A.D. 1764.)

Of the Sun standing still, & the shadow On Ahaz's Dial going backward.
See much better in Parkhurst's Heb. Lex under עלה, p. 475. the 2.d Edit.

Two Cases

Objection

Argentum Mosaicum.

The German powder for silvering small plaster busts, statues, or carved work, called Argentum Mosaicum.

One pound of very pure ~~tin~~ tin, melted in a crucible: when it begins to run into fusion, add to it an equal quantity of bismuth or tin-glass, and stir the mixture with an iron rod, or stem of a tobacco-pipe, till the whole be entirely melted and ~~incorp~~ incorporated. Take the crucible then from the fire; and, after the composition has cooled a little, but while in a fluid state, pour into it a pound of quicksilver, gradually; stirring it in the mean time, that the mercury may be throughly conjoined with the other ingredients. When the whole is thus commixed, pour out the mass on a flat marble stone; where, as it cools it will take the form of an amalgama or metalline paste, which will be easily bruised into flaky powder, and is then fit for use.

Measure of Fig.s for Dials, & ~~the~~ a computation of the Guilding upon one.

How used.

This powder may be either tempered with gum water; or rubbed over a ground properly sized with some white substance, as flake-white, or white-lead for oil; Whiting is used, or where the glover's or parchment size is used. Tobacco-pipe clay, with a very little lamp-black to give it a silvery greyishness, is still better: (and it will take a very elegant polish from a dogs tooth or burnishers, and holds its colour much better with a slight coat of varnish over it, than any true silver powder. d.D.o

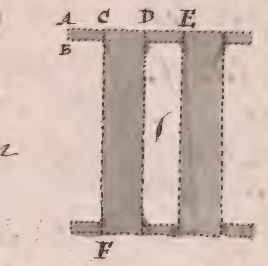
Counterfeit Amber.

A Composition in Imitation of AMBER.

Take the yolks of sixteen Eggs, beat them well together in an earthen Pan well glazed, then take two ounces of Gum Arabic, and one ounce of the Gum of Cherry-trees, reduce them into powder, and mix them with the yolks, that so they may dissolve, and be incorporated by stirring them frequently about; this done, set them for six or eight days in the sun, and they will by Degrees grow harder and harder. You may, before they are thorough dry, form or impress what you will in some mould, and lay them again in the Sun, or some warm place to dry, & whatsoever you have made, will look clear of the colour of Amber, and have its natural Qualities to draw up Straw or Paper.

Scripture places which assert the Earth's stability & the Sun's Motion

I am sorry to find, that the modern Wise-men make so light of the Scripture Philosophy, particularly from that famous Passage in Jos. X. 12, 13. of the Sun standing still; and the shadow of Ahaz's Dial going back ten Degrees, Isaiah XXXVIII. 8. In both which places the Word שמש Shemesh is wrong translated Sun, if by it we mean its Body or Orb; for it signifies only the Light, the Minister, Servant, or Attendant thereof. Thus the same Word Shemesh, Dan. VII. 10. signifies ministered or attended about him, like Light in Circulation about the Orb of the Sun; and in Ps. XIX. 5, 6. the Motion of the Shemesh is described by its coming out from its Orb; which is fixed; as is expressed here by חפת, and in Job IX. 7. by the Name חרס Ores, which Word I take to be compounded of חר to burn, and רס to mix; חרס Ores then is the Fire at the Orb, where what produces Light is mixed; and whence שמש the Shemesh is poured out to perform its Operations. So that the Truth of the Matter both in Joshua and Isaiah seems to have been the stopping or making the Light recede on a particular Point of that Hemisphere. 'Tis hard to determine, whether this was an extraordinary Production of Light, like the Cloud, &c. in the Wilderness, or an over-ruling the Shemesh in its Operations, and thereby stopping the Globe in its diurnal Rotation: I am inclined to think the former was the Case; because if the Earth's Rotation was suspended, a Series of Miracles seems necessary to have prevented a Variety of inconveniencies attending the sudden Suspension of the Earth's Revolution, such as over-turning all the Buildings upon it, occasioning immense Inundations, and the like. Any one May easily conceive, were even a Ship under full Sail to be stopped suddenly, that every thing moveable on the Decks would be carried to a great Distance; and how vastly does the Motion of a Ship fall short of the other? Aboab, on Xanity Preface. p. 13 & 14.

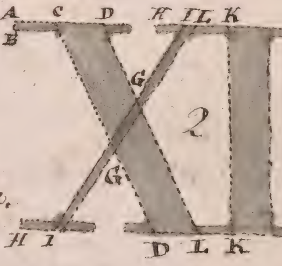


The ~~Proportion and~~ measure of very good Proportioned Figures upon a Dial, I have taken with a Scale of half an inch, as follows.

Fig. 1. CD = 1,38
CF = 10,8.
AB = ,25.
AC = ,5.
Fig. 2 & 3. DI = 1,84.
DG = 3,68.

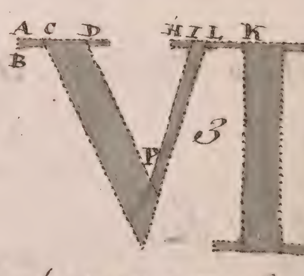
Fig. DE or
Fig. 2, 3 I,K = ,95
DP = 5,25.

N.B. These Figures annexed are not drawn after these proportions particularily DI in fig. 3 is much too wide.



The Superficies of the Gold upon The Rev.d Mr. Trotter's Dial which I had guilt for him, I have computed, as follows.

Superf. Inches
381,528 Moulding round the Sides.
95,0334, Sun, or Ornament in the Center, & Motto from Matt.
115,516. Broad Strokes of the Figures.
4,428, little D°.
112,5, Stile, Supporter, & foot



Sum. 709,0054 Inch allowing 9 Square inches to one leaf of Gold, makes 78,7783 Leaves = 3 Books & $6\frac{3}{4}$ leaves, allowing 24 leaves to a book (which is bought for 2.s) but sometimes $3\frac{1}{4}$ inches in the Side of a Square leaf of Gold, or 10,5625 Square inches, at which Rate 67,1 leaves or 2 books, 19,1 leaves are upon the Dial.

Our Translation of the Scripture seems to assert the immobility of the Earth, and the Motion of the Sun & heavenly bodies, in these passages, 1 Chron. 16. 30. Ps. 93.1. Ps. 96.10. Ps. 104.5. Eccles. 1.4. Ps. 119.90. Gen. 19.23. Gen. 15.17. Eccl. 1.5. Ps. 19.5. Josh. 10.12, 13. 2 Kings 20.10. Isa. 38.8. Holm's Grammarian's Geography & Astronomy p. 22

Counterfeit Coral.

To make Coral Branches, for embellishing of Grottos.

Take clear Rosin, dissolve it in a brass-pan; to one ounce thereof add two drachms of the finest vermillion: when you have stirred them well together, and have chose your twigs and branches, peeled and dried, take a pencil and paint these twigs all over, while the composition is warm, and shape them in imitation of natural coral of Black Thorn; when done, hold it over a gentle coal-fire; turn the branches with your hand about, and it will make it all over smooth and even, as if polished. In the same manner you may with white lead, prepare white, and with lamp black, black Coral.

Artificial Grotto, how made for little expence.

A beautiful Grotto may be built at a very little expence with glass cinders, which may easily be had, pebbles or pieces of large flint, and embellish it with such counterfeit coral, amber, (v. p. 17.) pieces of looking glass, oyster shells, mussel, and snail shells, moss, pieces of chalk, oar, &c. The cement to bind them together is as follows.

A Cement.

Also, the flower of Sulphur may be omitted

To mend broken China & Glasses.

Anoint the edges with the juice from a few cloves of garlic, beaten in a mortar, and the stick them together, which will cement better than by any other method.

Take two parts of white rosin, melt it clear, add to it four parts of Bees-wax; when melted together, add stone-flower, of the stone you design to cement, two or three parts, or so much as will give the cement the Colour of the stone; to this add one part of flower of sulphur; first incorporate all together over a gentle fire, and afterwards knead it with your hands in warm water. With this, cement the stones after they're well dried and have been warmed before the fire, in order to receive the cement the better. General Mag. Feb. 1764. p. 88. See the Complete Dictionary of Arts & Sciences under the word Cement.

A Cure for the Gravel. or Stone. Vide. p. 21. also Vol. II. p. 17.

Oister shells (the older the better) burnt till all perfectly white: One pound of the Ashes dissolved in 12 lb of Salt warm water by often shaking or stirring it & standing 36 or 48 hours to settle. Half a pint of this Lime water lukewarm & a little milk or cream in it taken fasting & at night just after, at first, 3 or 4 Pills of Castle Sope; ~~and~~ after sometime the pills may be increased to as many as the person can well bear. This in time will certainly cure the Gravel, or Stone, in either Sex. Dr. Whytt's method, in Vol. 22. of Gents Mag. 1752. p. 573, is to use 7 or 8 lb of water to 1 lb of calcined oysters. & he gives 4 pints a day to a man, and 2 for a boy of 8 years old.

Violent bleeding, how stopped.

Fungus maximus rotundus, The larg Spongey mushroom, gathered when dusty & kept for use, will stop any bleeding whatever, by only applying a little bit of it to the wound & binding it pretty hard thereon. A Sponge will in some measure answer the same end.

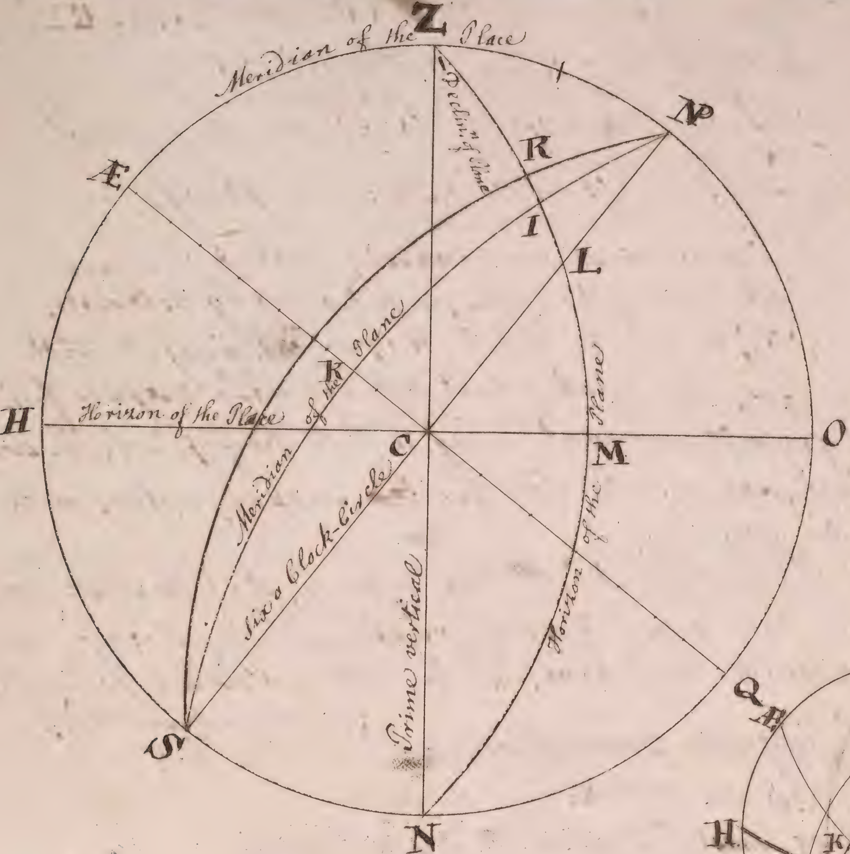
Glass Stained.

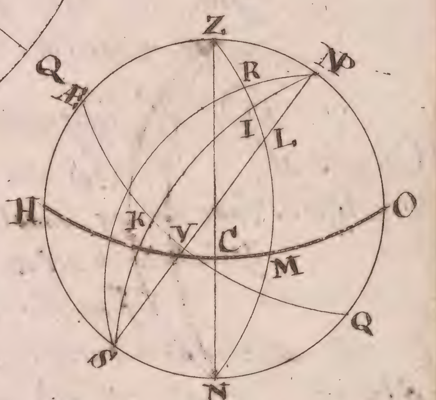
Oyl of Spike mixed with any Colour, and Glass finely painted therewith, presently dries, penetrates the Glass & leaves it transparent. Philos. Trans. No. 245. Vol. I. p. 207. of Jones's Abridgmt.

Right Ascen. Decl. &c. of N. Pol ✱ and Alioth for 216 Years. V. p. 111 & 112.

I have not only Calculated but Corroborated by a triple operation the Right Ascension, Declination, & the Angle formed by the Circle of Latitude & Meridian passing thro' The

		Longitudes	Latitudes	Rigt. Ascensi.	Declinations	Angle of Circ. of Lat. & Merid.
North Pole Star, in the year	1693	♊ 24°. 17'. 11"	66. 4. 11 N.	8°. 20'. 46"	87°. 40'. 33" N.	77. 24. 34
	1765	♊ 25. 17. 11	66. 4. 11 N.	11. 5. 46½	88. 3. 12 N.	74. 35. 15½
	1837	♊ 26. 17. 11	66. 4. 11 N.	14. 57. 56	88. 26. 31 N.	71. 40. 4
Alioth, in the gt. Bear's Tail in the yr.	1693	♍ 4. 33. 55	54. 20. 16 N.	190. 7. 59	57. 22. 16 N.	42. 17. 11
	1765	♍ 5. 33. 55	54. 20. 16 N.	190. 56. 10	57. 16. 30 N.	42. 9. 2
	1837	♍ 6. 33. 55	54. 20. 16 N	191. 43. 55	57. 10. 18 N.	42. 0. 21
	1772	♍ 5. 39. 45	54. 20. 16 N	191. 00. 58,76	57. 14. 13,65	





For Dialling

In the Fig.r above

HZON is the Meridian of the Place

HO, the Horizon of D.o

ZN, the Prime vertical, which goes thro' the Zenith **Z**, & Nadir **N**, cuts the Horizon at Right Angles at the point **C**, in such a Manner that the Spherical Angle **OCN**. or **ZCO** may be Right.

ZMN, the Horizon of the Plain, whereof the Spherical Angle **CZM** is the declination. & the Angle **MZO** the Complement

NPIS, the Meridian of the Plain, going thro' **NP**, **S**, the two Poles of the World, and cuts the Horizon of the Plain at Right Angles in the point **I**, and the Equator **ÆQ**, at the point **K**, ~~in such a manner that the Angle of the Axis with the Substilar, or the Height of the Pole above the Plain may be the Arch~~ **NPI**

NPI is equal to the Angle of the Axis with the substylar, or the Height of the Pole above the Plain.

ÆK, the difference of Longitude of the Plain, or

or $\angle$ **ÆNPK**, is D.o

NPLS, is the Six a Clock Circle, cutting the Horizon of the Plain, at Oblique Angles, in the point **L**, and the Equator **ÆQ**, at Right Angles, in the point **C**, or **V** in fig. 2.

1. To find the Height of the Pole above the Plane IN P.

In the Right-angled Spherical Triangle **ZINP**, Rectangular at **I**, the Angle **NPZI**, the Complement of the Declination, of the Plain, and the Hypothenuse **ZNP**, the Comp. of the Latitude of the Place, ~~Whence~~ are known, whence this Analogy

As Rad : S. **ZNP** : : S. $\angle$ **NPZI** : S. **INP**. required

2. To find the difference of Longitude.

In the same Triangle the former requisites are known to find $\angle$ **ZNPI**, ~~the Complement~~ the difference of Longitude

As. Rad. : S. **ZNP** : : Tang.t **NPZI** : Tang.t **ZNPI**. the Diff. of Long. required.

3. To find the Angle which the Substylar makes with the Meridian, or the Arch IZ. of the Horizon of the Plane, comprehended between the Substylar and Meridian, of which IZ is the measure, and to find it there is the same data in the same Triangle IZNP, Therefore.

As. Rad. : Cos. **IZNP** (or S. Plane's Decl.n) : : Tang.t **ZNP** : Tang.t **IZ**, the angle of the Substylar, ~~required~~, with the Meridian, required, and is the same which the

A Receipt to cure the STONE and GRAVEL, communicated in a letter to the Right Revd Thomas Ld. Bishop of Kildare, by Thos Butler, Esqr of Warminster in Wilts.

To cure the Gravel or Stone. See p. 33.

TAKE a daucus or wild carrot (of which there are plenty in all parts of England, well known by botanists, gardiners, &c.) and make it into tea, sweetening it with Lisbon sugar, and drink about two ordinary teapots full in a day, each pot containing a full half pint, the one for breakfast and the other for ~~tea~~ supper, eating with it as the other tea.

By this method Mr Butler asserts, that in three days time the pain began to grow weak and die away, in five days it quite left him, and he was restored to perfect health.

Cambridge Chronicle for May 31st 1766.

Dr Hasselquist's prescriptions, are

For an Ague.

Cures of the Ague. Take an egg, roast it in ashes till it is quite hard, sprinkle it all over with pepper, & eat it at once

For the Cholic.

Cholic, or Stone. Take the snuff of a candle, and German soap, mix them well and make pills, it is a sure remedy in the Levant.

For the wind Cholic.

Wind Cholic. Take three or four pills about as big as a pea, made of common pitch when the fit comes on.

For the Asthma.

Asthma. Take a sea-gull, chop it in pieces, boil it in water to a strong broth, and drink it at once.

Barrenness.

Barrenness. The man and woman must drink each a tea cup full of Clove water going to bed.

All Erect Declining Dials may be reducted to an Horizontal one in some other place.

The Stone in the Bladder, Kidney, the Trophi, &c. will not be dissolved, or in the least corroded by any of these Acids, Vinegar, Petrified Water Spirit of Vitriol, Aqua-Fortis, Spirit of Salt: though Spirit of Nitre is a general Menstruum & will dissolve it.

Philos. Trans. No 182. Vol. III. p. 177. l. 2–12. of Lowthrop's Abridgment.

"This yields to none (menstruum) but the most potent Acids, and particularly to Nitrous ones alone." ibid. p. 180. l. 37 & 38.

Apply Relaxing, and Strong ~~Emollient~~ Emollient Remedies to Dilate the urinary passage for the emission of it.

Ibid. p. 183. l. 19–21.

Ibid. Vol. V. p. 28A. l. 21. Considerations for the cure.

Equinoctial makes with the Horizontal-line: because in ~~this~~ Erect Dials declining from the South these ~~Ten~~ Two are perpendicular to one another, since the represent Circles which are perpendicular to one another; and One of those Circles is perpendicular to the Plane of the Dial, viz the Meridian of the Plane.

4. To find the Angle which the Six a Clock makes with the Meridian, or Arch **Z.L.** In the Right Angled ~~Triangle~~ Spherical Triangle **PL.Z**, Rectangular at **P** say

As Rad.: Cos. ∠**L.Z.P** (or S. of Plane's Declinn.) :: ~~Tang~~ Cot. **ZP** (or t. of the height of the Pole) : Cot. of **Z.L.**, the arch, required.

5. To find the Angles of other Hour-lines with the Meridian or Substylar. Let Suppose it were required to find the angle of 10 a Clock-line with the Substylar; let the 10 o'clock-circle be **PRS**, then will the Horary-distance or Spherical-angle **Z.P.R** be 30°, which subtract from the Angle **Z.P.I**, the Plane's difference of Longitude, there will remain **I.P.R**, and in the Spherical Triangle **R.P.I**, Rectangular at **I**, there may be found the side **R.I**, the Angle which the 10 aclock-line makes with the Substylar by this proportion

As Rad.: Tangt. **R.P.I** :: S. **I.P** (before found) : Tangt. **R.I**, the Angular distance of the 10 aclock-line from the Substylar, required.

Ozinam's Course of Mathmcs upon Gnomonics. Vol. 5. p. 93.

This last proportion for obtaining the Hour-lines from the Substylar, being the very same as for an Horizontal Dial in the Place **I**, the Complement of whose Latitude is **P.I** and difference of Longitude **Z.P.I**. therefore every Erect (at least) Decliner may be Geometrically constructed, like an Horizontal one, (shewn & demonstrated on the page facing the 5**A** of My M. S. of Spherical Trigonometry) by reckoning each hour circle's or the Time's distance ~~upon~~ from the Meridian of the Plane **SKP**, upon the Equinoctial **Æ.Q**, instead of the Time from Noon, in the said M. S. that is, in Short, Every Erect Dial ~~is an~~ in any ~~Horizontal one~~ Latitude, whether Direct or Declining, is an Horizontal one in the place **I**, And therefore may be calculated or constructed as such. — The Principles of Dialling are very well laid down in Gregory's Astronomy Vol. I. Book 2. § 6. Propo 42, 43, & 44. p. 331, to 336. He also has a Method of making an Horizontal Dial. Book 2. Prop. 15. p. 274.

If a dial be made according to the strict rules of calculation, and truly set at the instant when the sun is on the meridian; it will be a minute too fast in the ~~after~~ fore noon, and a minute too slow in the afternoon, by the shadow of the style; for the edge of the shadow that shews the time is even with the sun's foremost edge all the time before noon, and even with his hindmost edge all the afternoon, on the dial. But it is the sun's center that determines the time in the (supposed) hour circles of the heavens. And as the sun is half a degree in breadth, he takes two minutes to move through a space equal to his breadth; so that there will be two minutes at noon in which the shadow will have no motion at all on the dial. Consequently, if the dial be set true by the sun in the forenoon, it will be two minutes too slow in the Afternoon; and if it be set true in the Afternoon, it will be two minutes too fast in the forenoon. The only way that I know of to remedy this, is to set every hour and Minute division on the dial one minute nearer XII. than the calculation makes it to be. Gents. Mag. for May, 1767. & that from Ferguson's Tables & Tracts &c.

To cure a cough. — In most coughs where the matter is thick and tough, the juice of horse-radish mixed up with a little sugar, and now and then ten grains of calomel, is found an excellent remedy; in dry coughs a decoction of turneps with the juice of liquorish, is of great use. but when it arises from the stomach, a little like the cough in children, whose seat is in the stomach, emetics and bitters only can cure it. — This is the prescription of one of the first physicians perhaps in the world.

To preserve man and beast from Infection.

~~[illegible]~~ Lavender, Rue, Wormwood, and Sage, an handful of each put into a gallon of White-Wine Vinegar, set them upon wood ashes for four days; strain of the liquor into bottles, and put a quarter of an ounce of camphire into each bottle. The nose, mouth, & temples, of either man or beast, rubbed with this liquor will preserve them from infection.

A Certain Cure for Corns.

℞ Take plaister of Gum Galbanum with Saffron, Gum Ammoniac, Gum Diachylon, of each half an ounce: Camphire, two Scruples: mix them together. Spread it very thick upon a piece of linen cloth; but put no more upon the cloth, than will exactly cover the corn; for if more it will be apt to excite blisters upon the skin of delicate persons. The Effects will be expedited, if the feet are dipped in water, and the hard skin of the corn got off before the plaister is applied. Oxford Journal Jan.y 6th. 1787.

To cure the Scurvy.

To four beer quarts of good rich sweet wort, add half a pound of sassafras, one ounce of sarsaparilla, and four ounces of daucus seed (commonly called wild carrot): boil the gently over the fire for three quarters of an hour, frequently putting the ingredients down with a ladle; then strain the same through a cloth. To each quart of this liquor put one pound and a half of good thick treacle, boil the same gently for three quarters of an hour, skimming it all the time; put it into a pan, and cover it till cold, then bottle it for use. Be careful not to cork the bottle to tight.

Proofs of the Copernician System. Examine Rohaulti Physica Part. II. cap. 24.

Of this syrup a moderate tea cupful is to be taken in the morning, and the same at going to bed. — It will keep open the body, take off all the itching, clear the skin, ease the feet, relieve drowsiness, bring on comfortable nights, produce activity & vivacity of Spirits.

High Sauces must abstained from, and animal food used sparingly. Table beer, & now and then a little ale may be drank at meals.

N. B. The wild carrot ought to be gathered in September or October. Sassafras & sarsaparilla may be had at the druggists or Chemists.

Gent. Mag. for March 1789. p. 37, 38. where it stands very highly recommended. with an Example.

On the Solvent powers of Camphor.

Camphor and resins are two substances equally insoluble in water, yet when united form a smooth ~~equitable~~ equable mixture, which is reckoned very singular. The union takes place best when the proportion of camphor is about one to five; but it is also sufficiently close in equal weights. Also Mr. Chamberlaine (Memoirs of the Medical Society of London. Vol. II. No. 28.) found ~~mastich~~ mastick, balsam of tolu, gum benzoin, gum guaiacum, sagapenum, gamboge, and sanguis draconis, were dissolved by camphor in their order but each is dissolved less perfect than myrrh. Olibanum, assafœtida, and the purer gums, were unaffected. Critical Review. April. 1789. p. 267.

The Copernicorn or Solar System, drawn large and upon the principle of Elliptic Orbits, with the Ecliptic divided into ~~degrees~~ signs, degrees, and Months & days properly fitted thereto will shew, the order and revolution of the Planets; how the different Seasons are produced, with the Sun nearest in the Winter; the several phases or appearances of the Moon; her Apogee, Perigee, Syzygias, and Parallax; the line of the Apsis or Apsides of a Planet; its higher Apsis, or Aphelion; and lower Apsis or Perihelion; the Nodes; and line of the Nodes; Eclipses both Solar and Lunar; the true and mean Anomaly of the Earth & Planets; thence the Prosthapheresis, Equation of time, Eccentricity of their Orbits; how they may be in conjunction and opposition with the Sun and with each other; thence how Venus has the like phases with our Moon, which confirms this System against all others; the greatest Elongation of the inferior Planets Venus & Mercury; how a planet becomes an Evening Star for several Months, and after that, the same may be a Morning Star for a like time; the Annual Parallax of the fixed Stars; and the Path of a Comet; &c.

Criterians of the Copernican System.

1. If our Earth were in the Center, and the Sun, Venus, and Mercury finished their revolutions about it in such different Times, it must necessarily happen, that, while the Sun is on one Side of the Earth, Venus or Mercury must be on the opposite Side; as now the Earth and either of the Planets are frequently on opposite Sides of the Sun; because the Orbit of the Earth is exterior to that of Venus, or Mercury, they can never get to the Side of the Earth, opposite to the Sun. But if the Earth were placed in the Center, what happens to the Sun now would happen to the Earth then.

2. The other Planets appear to us, sometimes to stand still, and sometimes to move backward, instead of going forward, which is an Appearance they could not make to us, if we were in the Center of their Motions. - Since the Planets nearer the Sun perform their Revolutions sooner, on a double Account, both as their Motions are swifter, and their Orbits less; the interior or lower Planets must seem, by their swifter Revolution, to cast the exterior Planets behind them, or backward among the fixed Stars: and thus Mars, Jupiter and Saturn, must seem to us to move back a little among the fixed Stars, as our Earth passes betwixt the Sun and them with a quicker Motion: thus they appear to go backward while they really move forward. - Again, if Venus pass between us and the Sun, while Mercury moved on the other Side of him, though both proceeded the same way, or followed each other, yet they would seem to meet and Cross: Whence Venus must appear to go backward, or contrary to the order. This, which shews the Copernican Order of the Solar System

(*) In another place, Baxter says, "They who place the earth in the center of the system, and suppose the Sun to revolve about it, in the fourth place (namely above the moon, Mercury, and Venus) confound this beautiful law of the planetary motions: For, let us suppose the distance of the sun from us was but 12000 semi-diameters of the earth, or 200 times the distance of the moon; and then the cubes of their distances will be 8000000 and 1: The square roots of which numbers are 2828 and 1. So that the periodical Time of the sun ought to be 2828 times that of the moon: That is, either our present year ought to contain 2828 revolutions of the moon, each consisting of about three hours, six minutes; or our present periodical month ought to be the 2828th part of the Year; whence one revolution of the sun would be equal to 211 of our present years. Either of which is monstrous.

System and the motion of the Earth round the Sun, to a Demonstration, may be observed in Saturn and Jupiter every Year; and in Mars and Venus once in two Years.

3. But there is still a more noble Argument, the Times of the Revolutions of the Planets round the Sun; and their Distances from him, are so connected by a certain Proportion, which flows from a Natural Necessity, that one may venture to say, it is either Ignorance, or determined Obstinacy, that makes Men place the Earth in the Center of the System, since such a Disposition would ruin the most beautiful Proportion, and struggles (unsuccessfully) against the strongest Necessity. – The Proportion is this, The Squares of the periodical Times of the Planets round the Sun are always as the Cubes of their Distances from him. (*) Baxter's C.P.

4. Mr. Flamsted (in his Letter, sent to Dr. Wallis, the 20th of December 1698, ~~and~~ published in Dr. Wallis's Mathematical Works Vol. 3. says he) found the Annual Parallax of the Pole-Star 40 or 45 Seconds. But as his Instrument & steady position of the wall, to which it was fixed, are to be questioned; I should rather rely upon the proof drawn from several Stars appearing Split, double or triple, at one time of the year, and one or single at another, as the Celebrated Astronomer Mr. Cassini observed, that, the First of Aries appear as one single Star, but at another time, when the Earth was in its opposite point of ~~[illegible]~~ her Orbit, it appear Split into two equal ones, distant from each other about one of their breadth's. He also observed the like ~~in the first~~ from that in the Head of the first of the Gemini, that in Orion's Sword, & Belt, and some of the Pleiades, to be three or four times Split. Ozanam's Cour. of Math. Vol. 5 P.t 1. p. 95. also Gregories Astronomy Vol. 1. S 9. Prop. 54. p. 199.

5. Since the Orbits of the inferior Planets Mercury and Venus in the Ptolomaic Hypothesis are contained within that of the Sun, they can never be seen beyond the Sun, which they are observed to do as often as on this side of him: it likewise thence ~~also~~ follows, that the Sun may be in the West, Mercury in the East and Venus in the South, at the same time; which are Aspects that have never yet been observed. But on the contrary the greatest Elongation of Mercury is never more than 21 or 22 degrees, & of Venus 47 or 48 degrees, whereby the Absurdity of the Ptolomaic System is incontestably shewn.

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How to make Tutenag; a metal like Silver; White copper; & the chinese Packsong.

Two parts of tin and one of bismuth form Tutenag.

Ten Ounces of lead, six of bismuth, and four drachms of regulus of antimony, form a hard close-grained metal, as white as silver.

Copper and tin boiled together in a solution of tartar, or of tartar, alum, and salt, the copper will acquire a thin coating from the tin.

The Chinese metal, called packsong, is composed of copper, nicknel, and Zink.

Critical Review, June 1789. p. 415.

Light of Stars depend upon our Sun.

Zodiacal Light, what?
V. Dr Gregory's Astrono. Book II. prop. VIII. Scholium p. 288. Vol. I.

Properest time of Observing it.

A conjecture, about what it is.

Rain and Dew what each is, and their difference.

Attempt to find the Longitilde by the Moon's Anomaly.

It is plain, that the Light of the Fixed Stars, as well as that of the Planets is made to depend upon the Light of the Sun; because the Holy Scripture never makes any distinction between them, and especially in Revel. VIII. 12. where we read, And the four Angles sounded, and the third part of the Sun was smitten, and the third part of the Moon, and the third part of the Stars; so as the third part of them was darkened, and the Day shone not for a third part of it, and the Night likewise.

Ozan.^m's Course of Math.^s Vol. 5. part. I. p. 38

Add hereunto Jerem. XXXI. 35. Job. IX. 7.

The Zodiacal light is a brightness like that of the Milky way, and sometimes even brighter, extending almost along the zodiac, 50, 60, 70, 80, 90, & sometimes 100 degrees & more, from the place of the Sun on both sides. Its points and a great part of its luminous arch, when it is not enveloped, or mixed with our twilight, appear to have an annual and diurnal motion about the earth, like, that which is vulgarly attributed to the sun. — The properest time for observing it is in the evening, towards the end of winter and the beginning of Spring; and in the morning towards the end of Summer and the beginning of autumn. This difference is in effect of the different position of the ecliptic on the horizon, which makes the point of this light fall sometimes higher and sometimes lower. Its origin is pretended to belong to the Sun, it therefore has received the name of Solar Atmosphere, though it must not be confounded with that which immediately surrounds it, in the form of a very flat spheroid, of which the greater diameter is often 5, or between 8 & 9 times greater than that which is imagined from one pole to another. The extent of this exterior atmosphere is at different times so unequal, that its upper point is sometimes far short of the orbit of the earth, and sometimes runs far beyond it. — Some Philosophers imagine this light to be a spheroidal assemblage of small planets, as the Milky-way is nothing more than an infinite number of fixed Stars, so small as not to be perceptable; they even believe that those small planets turn about the sun the same way as the great.

Universal Mag. for Apr. 1764. p. 180 & 181.

The difference between rain and dew is this, the former is a clear and whitish water; whereas the latter is commonly clouded and a little yellow. The water of pure-rain, being distilled, has neither taste nor smell; but distilled dew has both; a certain sign, that there are oleaginous parts extremely subtilised, confounded with dew. — Dew differs, greatly ~~generally~~ according to the place where it is found. Universal Mag. for May. 1764. p. 244.

A PROPORTIONAL RULE of finding at any time the Moon's ANOMALY; her Motions at Appointment being first for the same time given according to celestial Observation; has been invented by SAMUEL SCARLYN, M. B. and was communicated on the 12^th day of last September to the Commissioners appointed by Act of Parliament for the Discovery of the Longitude at Sea, for the Examination. Cambridge Chronicle for Decem.^r 28^th 1765.

29 # Of Inoculation for the Small-pox.

From the Gent^s Mag. for March 1766. page 116.

A Sympathetic Ink. for secret writing.

Mr Urban,

a mistake in the signs of infection.

In your Mag. for November last (see p. 495.) you gave an account of Dr Gatti's mistaking the redness of inflammation, and pimples, round the orifice made in the Dutchess of Bouflers arm for Inoculation, as a sure sign that the infection had taken place.

What follows may possibly show how that mistake happened, and prevent the like again.

My being minute will, I hope, be excused; it is to make every thing plain.

Without mentioning the various methods used formerly, and in different places, to communicate the infection, I shall only say I have seen two.

1st way of inoculating.

For the one — form little balls of cotton or caddis, (charpie or scraped linnen) the bigness of a good pin's head is sufficient, soak these in variolous matter, and keep it in a box for use.

Then with the shoulder or edge of a launcet, make such a slight incision through the cuticle as just to bring blood, (yet most do not fetch blood) a drop is sufficient; the scratch may be from a quarter to half an inch long, if longer there is no harm.

Rub the caddis button carefully, a little time, on this hair stroke; and, laying a plaister over it, leave it on four or five days.

the case if it does not succeed. & when it does.

If it do not hold, the skin will then be as whole as if it had not been touched, but if it succeed, there will be a faint reddish line, which on a near inspection will be found open. This inflamation increases daily till the turn of the pox, &c.

Phænomenon of liquor rising in Capillary Tubes.

Confirmed.

I have inoculated about two hundred, mostly in this way, and always found the above appearance.

2d Way of Inoculat^n

In the other way — they make a deep and wide ~~incision~~ orifice, with the point of a lancet — into which they thrust a dossil of soaked caddis, and leave it in, with a plaister over it, as above.

Objections to it

A little reflection must make one sensible that this is really an issue (fontanel) and that the dossil serves as a pea to enflame and keep it open; and effectually puts it out of one's power to know whether it has succeeded or not, till the event informs him.

Pimples round the orifice.

What adds to the uncertainty is, that as pimples frequently rise round infected wounds, so do they also sometimes round

Continued on p. 31.

The Art of holding a secret Correspondence by the Means of Sympathetic Ink.

The secret of the ink of sympathy consists in two waters of different virtues. which, though very clear separately, become opaque and of a deep brown colour, after being mixed together. They are thus composed: a gallon of distilled vinegar, in which has been put an ounce of litharge of silver, is made to boil during half a quarter of an hour. This is the first composition. The second is made with a piece of quicklime, and a little orpiment, infused for four and twenty hours. in a sufficient quantity of water: Now very clean and well-varnished earthen pots must be used for this purpose. These two liquors must be filtrated separately, and they are found perfectly transparent. Their use is in this manner: You write, with the first water, what you would not have seen, and the writing disappears, the moment it is dry; but he who receives the Letter, by running over the paper a spunge tho' ever so little humected with the second water, the writing will begin to appear in the colour of a red bordering upon black. When those waters are newly made, & care has been taken to cover the pot close, in which the quick-lime was infused, it is not necessary that the humected spunge should touch the writing to make it appear; it will be sufficient to hold it over at a little distance. It has been frequently seen, that lime-water is so efficacious, that, after ~~lying~~ laying upon a table the letter written with the first water, and covering it over with a ream of paper, by pouring some of the second water on the upper leaf, the only that is made wet, its virtue will penetrate through the thickness of the intire ream, and the writing will grow black. The ink of sympathy acts and obtains its effect through a book, and even a wall. Cheats have sometimes made use of those secrets, in order to pretend to a more than ordinary profound knowledge & sagacity, by finding ~~an~~ answers to questions proposed by simple & ignorant persons, on blank papers & sealed up with Care. The physical cause of these phenomena proceeds from the force of the lime-water, and this force consists in volatile spirits, which pass through bodies with an astonishing subtility, and even extend to a considerable distance

Universal Mag. for Apr. 1761. p. 181.

Immerge two capillary Tubes into clear water, observe the height of the water in both, then take out one and break it off where the water stood within, and immerge it again in the water to the same depth with the other in which situation, ~~or if they are both in that being suspended~~ as well as perpendicularly ~~suspended~~ out of the water, the Liquor will stand highest in the longest Tube(*) which seems to shew, that the pressure of the Air at Top has some effect in this phenomenon. ~~under which~~ in the latter case, there always hangs a quantity of the Liquor at the bottom of both Tubes to counterballance the ascended Column within. If there be taken in the Tube a shorter column of the Liquor than will keep suspended, it may be made to rest any where therein by inclining the Tube, whereas by the Newtonian Attraction it ought to remain at rest and fixed to the bottom, because the Tube

(*) and will never rise to the Top of any one be it ever so short

being

p. 29. Continued.

Simple issues.

1st way recommended.

From what hath been said, it appears, that the certainty of known the effect soon, is one recommendation of the small wound — and giving little, or no pain is another. I have inoculated several sucking children that did not wince, or cry, at all.

The Cause of fluids rising in Capillary Tubes

On the other side, putting it out of our power to know if it has held or not, is the principal objections to large Orifices, and also a hazard of the blood washing away the matter when to large.

Depth & not the length makes the odds.

It is the depth, and not the length, which makes the odds, a scratch of an inch long, if superficial, heals sooner than a puncture of a quarter: An example will prove what is said above.

Examples of both ways.

About fourteen years ago, two boys and a girl were inoculated in one day, by the latter way. I was sent for the fourth or fifth day to see if it had succeeded: And I found the caddis buried in the wound; the lips inflamed, and beginning to suppurate, — but could not say, held or not. They continued mattering a considerable time: During which we were in suspence — because I had seen some wounds continue with a moist scab upon them full three weeks before the patient sickened, who had a favourable ~~sort~~ pox and did well.

At last all the three healed up without any effect. The parents of the girl then sent her to me, and I gave her the pock in the slight way. At the usual time she sickened and was uneasy for three days; was relieved by a favourable eruption, and lay not an hour longer, and continued well ever since. Have seen others also succeed after once missing.

The mother of the two boys had not courage to try again; and both, afterwards died of them in the natural way.

Your Magazine, I suppose, goes to Paris. — If Dr Gatti will be so kind as to acquaint us, whether the Dutchiess of Boufflers wounds were large or small, and the rest of the circumstances, he will oblige the public in general, and particularly,

A Scots Inoculator.

A Corollary, wherein The ~~Cause of Liquor~~ rising of Liquor in Capillary Tubes is accounted for

Some Orifices enlarge & others not.

P. S. Sometimes the orifice for inoculation enlarges to a little Ulcer, nay, I have heard of them, but never saw any, continue running sores. This has been imputed to their being too large at first; to me it seems mostly, if not altogether to depend on the habit of body.

Example.

I inoculated two sisters at the same time, exactly in the same gentle way, one of the openings spread till it could receive two or three peas; and only healed by the help of a little calomel. The other could scarce admit of half a pea, and in many others have seen the smallest rasure enlarge greatly, and a large orifice not widen at all.

No. of the pox

The numbers of the pox after inoculation seems also to depend upon the constitution, and neither on the bigness nor smallness of the wound, nor on the quantity of matter applied, a very great load being sometimes (Continued on p. 33)

being all equal in every respect, cannot be supposed to Attract most at the lower end, wheresoever it be, or if it should, it ought to remain there as before. ~~but~~ ~~Moreover Glass Attracting~~ Besides, that Glass should Attract many Liquors, as water here, and Repell Mercury is a paradox to me. -- Therefore to account for this otherwise, it will be readily granted, that in every Fluid, there is a Friction arising from all the Particles among themselves, and as there is, in all probability, such an effect among Homogeneous particles, there is consequently a greater among Heterogeneous particles; therefore the particles of all Fluids will move more freely among themselves than when they are mixed with, or adjoining to, any other substance whatever: Wherefore if the bottom of any vessel be covered with a fluid, the greatest friction will be in the particles adjoining to the sides of the vessel, and less in those than in these that lie next those, but greater than in them more remote from the side of the vessel; because the next thereto i.e. to the side are sluggish with a tendancy to ~~a~~ rest by friction. ~~And~~ these lying next them draw of particles from the side of the vessel will have still less friction than the second &c. Hence it is plain the particles lying near the side cannot have so great a pressure upon the bottom as those in the middle have, because they have not so fierce motion; therefore by the laws of Hydrostatics, this is the nature or property of all fluids, the nearer the side of the vessel the greater must it together with the Cohesion (of the fluid) be to restore or keep the like Equilibro. Wherefore, the fluid will be truely concave, as it really is in all such circumstances.

Now suppose as much Liquor to be put into the vessel as possible there can without running over, then it will stand even & with the largest above in the middle, as this ~~account~~ seems to contradict the former concavity of the Liquor, yet upon the very same principles it may be thus accounted for; as the friction at the sides of the vessel takes of part, and obstructs the Pressure at bottom of the vessel: so also this friction will obstruct the free motion of the particles at the sides in rising, when the vessel is thus filled there is more friction at top, because of more surface, than there is at any other height; and the particles there are less active than those in the middle, which have a free motion among themselves; so that a greater quantity is required in the middle than at the sides in order to keep an equal pressure at the surface against the sides: but how to account for the equilibrium at the bottom I do not yet know

From hence the phænomenon of Fluids rising in Capillary Tubes may be easily deduced; thus, in spaces so very small, the friction of the particles lying next the side, affects those lying next them, and these again the next following (from the side), and so on to the very center of all small Tubes; for all the particles are in contact with each other: hence it is plain, that this friction will take off some pressure at the bottom, and by the laws of Hydrostatics, it will require a longer column in the tube than out of it to counterballance the fluid surrounding the Tube.

Again

p. 31. Continued.

depends not upon the quantity of Matter nor Orifice, but on the Constitution:

the consequence of an extreme small quantity, and a few after large dossils, and the same as to incisions.

Hence, there is no need to contrive instruments to make all the wounds alike; make them superficial, and small, if you want to be soon certain of the effect, &c. &c.

Genuine process of the composition for gilding Brass and Silver.

To gild Silver and Brass

Take two ounces of gum lacca, two ounces of karabe, succinum or yellow amber, forty grains of dragon's blood in tears, half a drachm of ~~saffron~~ saffron, and forty ounces of good spirit of wine; infuse and digest the whole in the usual manner, and afterwards strain it through a linen cloth.

See Philos. Trans. No. 243 p. 296. Vol. III. p. 657. of Lowthorp's Abridgment

The Principles thence conjecturely deduced

When this varnish is to be used, the piece of silver or brass must be heated, before it is applied; by this means it will assume a gold colour, which is cleaned when soiled, with a little warm water.

Note, This composition known only to a few, had been long used here in England. In 1720, it was communicated to M. Hellot by M. Scarlet, and in 1738 to the late M. Du Fay by M. Graham. M. Hellot this year communicated it to the French Academy, who thought proper to make it public. Univ. Mag.

To make lime water

To cure the gravel & Stone. See p. 21.

Calcine oister or cockle-shells and eggshells in the fire till they are friable and quite white; for if they are blackish or grey they must be put again into the fire; 7 pounds or at most 8 pounds of water mixed with one pound of these calcined shells, in an earthen vessel, and stand sometime; about 4 pints may be drank by a man and 2 by a boy per day; which and ~~eat~~ eating pills of soap, ½ an ounce at first, but in time ~~but~~ to be increase to an ounce per day, has cured extraordinary case of the Stone & gravel. See London Mag. for Novem. 1752. p. 519 — 519. extracted from an Essay on the virtues of Lime-water. By Robert Whytt, M.D. F.R.S. &c.

The rising of Liquor in capillary Tubes will not account for vegetation.

Fluidity, not from Spherical Particles, but

Again, if the tube be taken out of the fluid when it is risen to its full height, there will be a small bubble of the fluid hang at the end of the tube; which is of the very same consequence as if the tube just touched the surface of the fluid; and the reason of its hanging there is by the circumambient mediums pressing equally on all sides, except on that taken off by the end of the tube; so by hydrostatics or universal laws of nature, the stronger parts of the fluid will press toward the weaker until the equilibrium is restored against the end of the Tuble. It is conjectured that the Ratio of the heights to which ~~any~~ fluids will ascend in the same capillary tube, will be nearly as the specific gravities of the fluids reciprocally; but yet mercury will rather sink than rise. it is likewise thought, and has been tried with success in several fluids, and with different substances, that by immerging any solid specifically heavier than the fluid, it will rise with a convexity about the body at the surface, and by a narrow examination it will appear to stand close round the body concave towards the bottom: but if a body specifically lighter than the fluid, be immerged, it will be concave about the body at top of the surface and convex towards the bottom just under the surface: the cause of which remains a secret with me at present. W. J.

Hence I am led to presume there is a complication of three different effects of Fluids rising in capillary tubes. viz 1.st that of Friction; 2.nd the pressure or action of some medium or fluid at top of the tube, since it does not rise so high in a short one as in a longer, tho' both are of the same bore; this cannot be the Air, because we found the very same effects in an exhausted Receiver. See likewise S.r I. Newton's Optics p. 367. Quere Ult. but it might be worth while to try the same experiment again in vacuo, tho' it has appeared to succeed equally the same therein as in open Air. 3.rd Whether the Fluid be specifically lighter or heavier than the tube, because of fluids standing concave or convex at the surface about an immersed body accordingly as that body is specifically lighter or heavier than the fluid. And likewise that mercury will sink with a capillary tube of Glass.

W. J. took the section of a capillary tube and of the plant called the Sun-spurge, upon examining them we discovered the tubes about the center of the plant to be much larger than that of the capillary tube and likewise the specific gravity of the juice in the plant heavier than water, yet the juice rose upwards of 2 Feet ½ in the plant, whereas water would not rise in the tube of Glass (of less bore) to the height of 2 Inches. Moreover, the sap in vegetables only rises at a stated season of the year and at stated hours of the sun's appearance: From which two cases it is evident, the rising of liquor in capillary glass Tubes is not similar with vegetation and therefore cannot be accounted for thereby.

Light is the only natural Fluid in the Universe and all others are accidently produced by it, because it will give fluidity to solid masses and take it away from fluids, as Gold, Silver, &c. by infusing a sufficient

35)

Effects of Emetic Tartar by external Absorption.

Emetic tartar, in a quantity of about five grains, rubbed in at night upon the hands, after some hours produced a nausea; the next morning copious perspiration, and afterwards a tendency to increase the discharge of urine, and a little greater power in procuring some lax stools: nine grains were followed by these effects in a greater degree. The author Mr. S. suspects, that this this way of employing antimony may have particular advantages in ~~ulcers~~ cutaneous eruptions.
Crit: Review. May, 1789. p. 348.

from Light or Heat.

How vegetation may be accounted for.

To cure the Kinkcough by Hemlock.

In the monthly Review Vol. 50. Janr. 1774. p. 45. is a Review of "A Treatise on the Kinkcough. with an appendix, containg an account of Hemlock, and its Preparations. By William Butter, M.D. Fellow of the Royal College of Physicians, Edinburgh. 8vo 3s. sewed. Cadell 1773. — Here Hemlock is reckoned specific in the disease of the Kinkcough (commonly called the chincough) and after enumerating many of its virtues, the Dr. gives this receipt

2½ Ounces of spring water 0½ Syrup of pale roses 1 Grain of Hemlock-pill	to be mixed and taken in several doses, so as to be finished in the 24 hours.

The quantity of hemlock is to be gradually increased from one grain to 10 or 12 grains, according to the age of the patient, or the effect of the medicine.

Cramps cured by applying the finger to the moisture under the toes, and smelling to it every night at going to bed.

A Discourse on Pain. Preached at Bath. By James Fordyce, D.D. 1791. In a note at p. 43, the Author relates the following remarkable cure of the Cramp.

He has, for some years past, been happily relieved from the exquisite torture of the Cramp in his legs and feet, to which he was long subject in the night-time; insufferable pain frequently forced him to spring out of bed, till the contractions went off, whatever might be the season of the year, or state of his health; nor had he, from all his equries and experiments, find any better remedy, till mentioning it to an acquaintance, who kindly recommended to him a preventive, which had proved to himself, and many others, whom he intimately knew, as effectual as it was easy; however unaccountable it may appear, and perhaps to some ludicrous. It was simply this, touch with the finger, at going to bed every night, the moisture under the toes, and hold it for a moment to the nostrils. The method was tried, and succeeded perfectly, to the unspeakable comfort of him who now tells it. Let physicians find out how the effect is produced. He is content to feel and ~~assert~~ assert its reality in his own instance. The relief took place at once, and has continued ever since; unless when the practice was omitted through inattention; or in catching cold in the legs or feet, from want of due care to keep them dry and warm, both by day and by night.

Thence Animal growth.

Sr. Isaac Newton's Laws of the moon defective. with the correction.

degree of this natural fluid, or Heat, will become fluid; Water and other liquids will congeal into ice & become a solid mass by withdrawing this same natural fluid. whence it appears Fluids are not essentially made so by the Form or Sphericity of their Particles, (as most imagine), but by the different degree of Heat or Cold they are mixed with. W. J.

In the vessells of every Vegetable, the Heat of the Sun expands the inclosed Air, raises steams from the Earth through the root to acertain Height, and when the night comes, the Cold contracts, both the air within, & the ~~vessels~~ whole vegetable itself into a less space, & presses up the inclosed steam, lodges it at the extremity, and the augmentation is called Growth. It is evident the moisture is thus forced because the vegetable being cut near the bottom will bleed, which is not the Case with a Capillary Tube where it is not so forced. In the winter the Heat of the sun is not generally sufficient to produce this effect, though at the poles it is from a long duration there; consequently all spring or forward plants or those near the poles are very short, because the small degree of the sun's action upon them. On the contrary, all autumnal or latter vegetables and those near the equator are very tall, because the sun has acted upon them with a great degree of heat. Many instances hereof might be produced, as the Snow drop in our climate, and the Cedar ~~at the equator or~~ in hotter climates, or at the Equator. W. J.

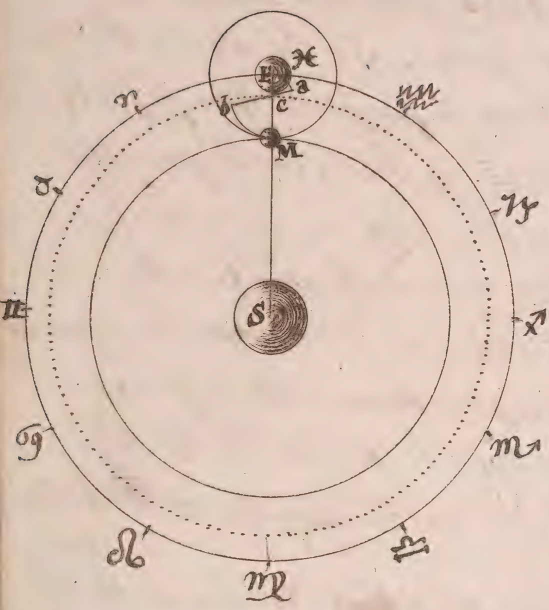
This steam and root of a vegetable are exactly similar with the food and stomach of Animals. W. J.

According to Sir Isaac Newton's laws of Gravity, the moon should be to the earth just as the earth is to the Sun, in all her motions and laws, except some difference of the same effect; but our earth has a diurnal motion round its own axis, & the moon has no such motion, notwithstanding our earth, has its cause, the power of Gravity, as well as that of the Sun; therefore gravity cannot be the cause of the moon's motions, as laid down by S.r Isaac, and the only true and rational cause thereof is this; as our earth is situated in the focus of the moon's Orbit, just as the sun is in that of the earth's, it is plain, as by S.r Isaac's Hypothesis, that the earth must act with all its capable power, upon the moon, under the very same laws as the Sun acts upon our Earth. but our earth is not a body of fire, that continually sends forth streams of light like the sun, and so is deprived of the powerful ~~agent~~ effect, the emission of light; which experiments verify to be the sole cause of a body's moving round its own axis, and the earth cannot give a power which it has not; Therefore the moon cannot have a motion round her own axis. W. J. from D.r Grew. F. R. S. — My objection to

An objection, proving the moon to move upon her own Axis

the same answ.rd

Heathens, called the power, which keeps the earth and moon together, Æther, & worshipp'd it under the Emblem ~~name~~ of a Tether.



The Newtonian reason why the Moon does not abandon the Earth.

(*) There is no reason in the world why this difference should be taken; for the difference between the mutual attraction of S and M, here nearly equal to 34889024, and that ~~of E~~ between the mutual attraction of E and M, here nearly equal to 17361120, is 17527904, the force with which the moon tends towards the Sun S, more than that towards the earth E; and therefore must abandon the earth.

Illustrated, by the attraction of the Earth upon a Drop of rain.

† Then the attraction of the earth upon this drop is greater than the attraction of cohesion in the drop itself: and yet it is immediately said, that this attraction of cohesion in the drop is greater than the attraction of the earth upon it; which is a contradiction in terms.

to this is: As the motion of bodies round their own axis does not respect or depend upon the manner of the light's action, but solely as its strength. And the light of the ~~moon in conjunctions~~ Sun upon the moon in conjunctions, is much more copious & powerful upon the moon than upon the earth; therefore, why should not the sun communicate a Rotary motion to the moon as well as to the earth.

W. J. answered this objection by saying, that the manner of action is half the effect: for the Pressure upon the moon towards the earth is greater than the action of light upon the same hemisphere from the sun, whereas in my objection I made the influence of the earth upon the moon nothing. it is also plain that because the moon has the same face turned towards the earth they are bound & tied together as it were with a Chain; the Heathens worshipped this power, which they called Æther, under the ~~name~~ Emblem of a Tether.

W. J.

In figure 1. on page 37. the distance of E, the earth, from S, the Sun, is 81000000 Miles, and from M the Moon is 240000 miles; thence SM is = 80760000 Miles: the Quantity of matter in S to that in E is as 227500 to 1; and in M to that in E is as $\frac{1}{40}$ to 1. Now Attraction is well known to act as the quantity of matter directly and square of the distance reciprocally; whence the attraction of S upon E is as 34674600, and upon M (at New Moon) is as 34889024 (but at Full moon it is as 34470024) also the attraction of E upon M is as 17361120 which is 81 times greater than the difference of S upon M and E.(*) Therefore M cannot abandon E at any time by the attraction of S; and the path described by M must be Concave towards S throughout. "The absolute attraction of the earth upon a drop of falling rain is much greater than the absolute attraction of the particle of that drop upon each other, or of its center upon parts of its circumference;(†) but then its side next the earth is attracted with so very little more force than its center, or even its opposite side; that the attraction of the center of the drop upon its side next the earth is much greater than the difference of force by which the earth attracts its nearer surface and center: on which account the drop preserves its round figure, and might be projected about the earth by a strong circulating wind, so as to be kept from falling to the earth. It is much the same with the earth and moon" Supposing "the moon's Orbit to be filled with a fluid Globe and the earth in the center" so that they cannot abandon each other, and if the projectile force were to cease they would fall together into the Sun, as a drop of rain does to the earth in calm weather;

from

(39)

If the velocity with which a body would describe a Circle at the point of Projection, be an unit or 1, then the least velocity that would throw a body or a Planet quite off through the ambient space, describing a curve which does not return upon itself, nor inclose Space, but runs out still to a greater distance will be as 1,A1A2&c. so that with the velocity 1 a body describes a circle, but with more than 1, and less than 1,A1A2 (or one & nearly an half) it describes an ellipse, and with more than 1,A1A2 it flies quite off.

Baxter's C. P.
Vol. II. p. 152. Ed. 12mo

My objection to the 1st account.

(*) i.e. the attraction of the New Moon upon the Sun is as (,36) 3833076, at Full as (,36) 3787915; the attract of the Moon upon the earth is as (,22) 43A0279, and that of the earth upon the Sun is as (,16) 152A16.

A consequence from both, contrary to all Nature.

I have since very carefully calculated the Attraction of the Sun, Earth, & Moon upon each other, and find them stand thus;

	Logarithms	Natural Numbers
S upon E ----	$\overline{89}$, 5A0011A =	(,10) 3A67A6
S upon New M —	$\overline{89}$, 5A25888 =	(,10) 3A881
S upon Full M —	$\overline{89}$, 537AA16 =	(,10) 3AA7002A
E upon S ----	$\overline{8A}$, 1830300 =	(,15) 152A16
E upon M ----	$\overline{89}$, 2395776 =	(,10) 1736112
Full M upon S --	$\overline{6A}$, 578A002 =	(,36) 3787915
New M upon S --	$\overline{6A}$, 5835A7A =	(,35) 3833076
M upon E --	* $\overline{78}$, 87, 6375176 =	(,21) 43A0279

Supposing each of the same density; but same authors say they all differ very much in density. v. Principia.

Gamaches shews that the motion of the Earth & Moon will always be Retrograde upon the Newtonian Principles.

*This is evidently a mistake, for while E goes forward in the order of the signs, ♈, ♉, ♊, &c. from right to left, the earth at a goes in the same direction from a to E, and the moon at b, in a contrary direction, from b to M while the point b from a, or line ab, will appear to pass through all the signs of the ecliptic in a direct order.

The point of equal Attraction between the	Miles from the S	Miles from the E
S & E =		
S & New M =		
S & Full M =		
S & N.M+E =		
S & F.M+E =		
E & M =		

The Distance of the Center of Gravity between	Miles from S	Miles from E
S & E =		
S & New M =		
S & Full M =		
S & N. M with E =		
S & F. M with E =		
E & M --- =		

Sr I. Newton's Projection & Attraction will not account for the motion of Planets & Comets.

from which, and the case of a Ship sailing round the earth upon this fluid Globe, it is plain that the earth cannot go without the moon, at full, to the Sun, no more than the moon, at new, without the earth. "And as the moon's projectile force keeps her from falling to the earth, so the earth's projectile force keeps her from falling to the Sun. Ferguson's Astronomy p.142 Article 275.

Since the Sun only attracts the earth and moon, do they not, in this account contradict their own principles of mutual attraction? Nay there is a contradiction in the account itself; for attraction is as the quantity of matter directly and square of the distance reciprocally, why then do not the earth and moon attract the Sun in that ratio? and likewise, the moon attract the earth as well as the earth attract the moon? But alas! they had better eyes than to see this, which would spoil all; for the (*) mutual attraction of the sun and moon, at New, is as 866865, at full as 861456, the mutual attraction of the ~~sun~~ earth and moon is as 431028, and that of the earth & sun is as 3467 4600, which superiority will spoil all if taken into the account, though it be upon their own Principles. —— Again, since E attracts M (at their conjunction with the Sun) with more force than S does, it might easily be demonstrated that E and M must describe the arches E a and M b round the common center of gravity C with a retrograde motion or contrary to the order of the signs (*) while the point C describes the dotted Orbit with a direct motion or in the order of the signs, and act at E and M, b and a as if E M, a b were two Leavers sustained by a fulcrum at C. This must be the case both in their own account with a simple attraction and according to their Principles with a mutual attraction; but astronomers never yet observed either the earth or moon to be Retrograde; therefore this Newtonian account, so much boasted of, will not stand the test of observation. And their other account from the Projectile force only, is as little to the purpose and was invented merely for a refuge in case of being attacked in the other: so the whole is only a mere quibble. Pere de Gamaches Astronomie Physique. V. Rowing's Philosophy Part IV. Chap. XVIII. p. 248.
& Sir Isaac Newton's Principia. p. 398. & 410. Edit. 3.

It is well known that the Planets describe equal areas in equal times, and the Area described by a Projectile in a given curve is as the velocity, or generating force; but according to Sr. I. Newton's laws of motion the projectile motion is much the swiftest in a planet's Aphelion, and therefore ought to describe the greatest Area in an equal time than in any other part of its orbit for the same time; because the arcs are as the velocities: ~~and~~ on the contrary, when a Planet is in its Perihelion the attraction prevails and the projectile force is weakest, therefore ought to move thro' a less arc in a given time than in any other part of its orbit, and consequently describe less Areas than before: all which are contrary to reality among themselves and

Upon the NONIUS.

Let ABCDEF (Fig. 16.) be a right-line divided into any Number of equal parts, n; and abcdefg another right line equal in length to the former, divided likewise into a number of equal parts, n+1; let these two lines be contiguous, and even at their extremities; which then are the only divisions that will concide; and if the position of one ag be altered by sliding along AF, the extremties A and a, F and f will no longer concur; but some one of the others may, as D and e, in which situation no other division upon AF can concur with any division upon ag. For, putting P = one division AB, and p = ab; Then $Bb = P - p = \frac{P}{n+1} = P - p = \frac{p}{n}$, when the extremities A & a, F & g. concur, and Cc = twice, Dd = three times, Ee = four times, &c. the distance Bb: Now the two Lines AF, ag, being contiguous, & moving parallel so as the two divisions at D and e may concur; then it is evident no one of the divisions upon the left ~~right~~ hand of D is so far from ~~a~~ its corresponding division from a, upon ag. it will have moved over a space greater than its distance from its corresponding division, and therefore will not concur with it, and not having moved over space sufficient to reach the next, it concurs with no division: so likewise those on the right hand of D, as E, being farther from its corresponding division e, than D is from e, and not so far from f, E will move over f, but not reach g; and therefore conjoined with none. the same may be said of all the othe divisions on the right: or when any other two divisions are conjoined. After the same manner may it be proved, that no one of the divisions may be conjoined.

When ag, which has the most divisions, is the moveable arch, and AF the fixed limb, it then is a Nonius of the first kind, & is mostly prefer'd as in Hadley's Octant: but when AF moves upon the fixed limb ag, it then is a Nonius of the second kind. V. page 45..

To place the first Hair in a Telescope in the Center of the Glasses.

To fix the second Hair at Right-angles with the first.

Of fixing a telescope to a Quadrant.

Tycho Brahe, in subdividing his Quadrant with diagonal Lines, says, the space included between the exterior & interior concentric circles, should never be more than $\frac{1}{48}$ of the Radius; and ~~but~~ by how much less than $\frac{1}{48}$, the more exact will the subdivisions; and that all the concentric circles must be accurately equidistant. In all which the moderns agree, though for what reasons, I am ignorant. Because, in fig.s 21. & 22. let AB be the Arch of one degree to the Radius AC or CB, and let AE or BD be $\frac{1}{48}$ of the radius, draw the concentric arc EGD, then are the arcs AFB, EGD the exterior and interior concentric circles; and AQD, the Digonal Line, is cut by the arch IPK, which is equidistant both from EGD & AFB, in Q; thro' which if HL a part of the radius, pass it will divide the Arc AB unequally in L. Because the Sides AE, BD being not parallel, as AE, & BM are, but E & D incline to each other, ~~the Diagonal~~ & therefore D lying nearer E than M does, the Diagonal AQD will lye ~~all~~ above the diagonal AM, and consequently Q above P; So that the Arch ROS passing thro' the intersection of GE, (which bisects ED & AB) and AD, is that ~~will~~ which cuts the Diagonal AD at the proper place to divide AB into 2 equal parts; & yet this Arc ROS is nearer EGD than to AFB. and therefore the concentric circles cannot be equidistant, as Tycho Brahe, asserts. See p. 159.

Another way.

Again, Let ελδ & αμβ be the interior & exterior concentric circles, draw the Diagonal αδ, & Quinquisect the ∠C by the lines Cμ, Cμ, Cμ, Cμ, and transfer their intersections, η, η, η, η with the diagonal αδ, to the side δβ, & they will be all unequal. and nowhere conincide with the equal divisions θ, which are also transferred to the diagonal,

(Continue on page 48.)

and therefore Projection and Attraction will not account for the motion of Planets and Comets. W. J.

The best method of fixing cross Hairs to a Telescope is thus, In the focus of the Eye Glass or that of the object Glass with any number of Eye Glasses fix an Hair fast down, on one side of the Tube only, then fix the telescope in or near the plane of the Horizon and view some distant part thereof, the farther the better, place the hair upon it and as near the center of the glass as possible, ~~and~~ in which situation fix it to the other side of the Tube; then turn the Telescope but just half round and try if the hair cuts the Horizon as before, if it does, then is it exactly in the center; but if it does not, it must be made so to do by repeated trials. Mr G. Adams Mathematical Instrument maker to the Prince of Whales in Fleet street London

To place the other cross hair at Right Angles with this, chuse some artificial object at a good distance in the horizon, as a steeple, the Corner of a Church, house, &c. which are raised perpendicularly. direct the telescope to it and place it in the center of the glass with the hair (already fixed) upon the Horizon, let the hair be so placed across this as to run along the very edge of the steeple, Church, &c. turn the telescope just half round and place it as before; if the perpendicular hair runs along the same corner as before it is then truly placed, but if it should not it must be made to do so by repeated trials. Mr G. Adams. as before. Smith's Optics Vol. II. p. 317. Art. 817. &c.

A Telescope is thus fixed to a Quadrant. 1st besure of fixing it fast to the Quadrant in the manner & place designed. 2d Hang a line & plummet at the center; view some distant object in or near the Horizon, so that the intersection of the cross hairs may fall exactly upon the object, and precisely mark where the line cuts the limb, there stick a pin, or a fine wire. 3rd Take off the line from the center & hang it upon this pin or wire. 4thly Invert the Quadrant with particular care to have the telescope just at the same height from the ground as before. 5. Observe the same object, in the same manner as above, and if the line falls exactly over the center, the pin point is then in the true Horizon from which the divisions of the Quadrant must begin; and the telescope never altered afterwards: but if the line should not fall upon the center, as it most likely will not, the pin must be so moved in a Circle of that Radius until it does; then bisect the distance of these two places of the pin for the true Horizon or 0 degree upon the Quadrant from which the graduation of the rest must begin. Stone's transl. of Bion on Instruments. p. 152.

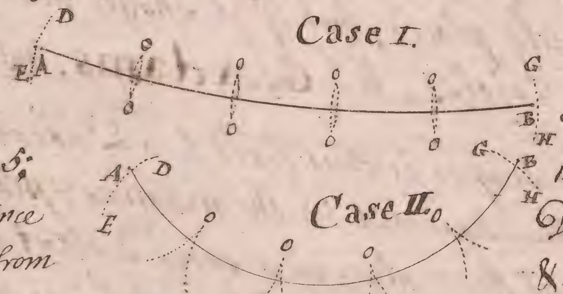
Another way is to observe two succeeding Meridian Altitudes of any fixed Star, once with the face of the Quadrant towards the East, and once towards the West; the bisection of these two Altitudes will give the point of 45 degrees. Bion. p. 152. last Edit. or p. 155 old Edit.

that they might the better be compared together.

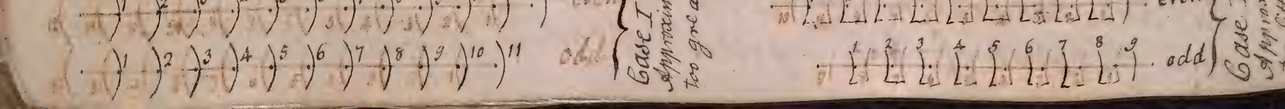
The Best way I can conceive to divide a Quadrant into degrees, is to calculate the chord of 8.° degrees and lay it off from ~~and~~ add it to 120.° and then by 64 bisections, the degrees are had, and whatever small Error should be in the Chord of the 8.° it will be bisected 64 Times, & thereby become very small, if anything in one degree. But if the Arch cannot be enlarged beyond a Quadrant, then take the Chord of 4.° and add it to 60.° (found by ~~twice repeating the Radius~~ laying of the Radius for a Chord) then 32 Bisections will give the degrees and the Error (if any) in laying of the 4.° will be divided into ~~64~~ 32 parts, & so become imperceptable in ~~a~~ single degree.

In finding this Chord of 4,° or of 8,° Whether or no it would not be better to find a Triangle whose 3 Sides shall be integers, & one of them the radius of the given Quadrant; and lay off this Triangle from the Center of the Quadrant, &c. &c. ?

Any arc (A) divided into a given number of parts (N = 90) nearly: and (B = 30) of these divisions to A; then divide A + B ~~into~~ (N + B) 120 parts by continual bisection, will be very nearly true of A divided into 90 parts. thus may any arc be divided into any given parts by bisections only.



To divide the Arc AB into any Number of equal parts, suppose 5; Approximate the distance very near; then begin from one of the points, as B, & at every division describe a small arch, the last of which, DE, will fall beyond the point A, if the approximated distance be too great, as in case I. But if that distance were too small then DE falls short of the point A, as in case II. Then with the same approximated extent, begin from the other point, as A, & at every division describe an Arch to intersect the former in the points o, o, o, o; through these intersections, and the given center, draw a Right line to touch the Arch AB which will give the true points of division required. This Method occurred to me whilst contemplating and writing the above, on the same Subject. Indeed the approximated distance must be very exact, ~~or else~~ for what ever error you set out with, that whole error will, by this way, insinuate itself into each of the divisions, as is Evident by inspection, from the Lines divided below, where the black dots upon the lines shew the true divisions, & the figures the repetition of the Error. So that this method can only help to draw the lines to a finer point.



To one already graduated.

A Telescope with two plano-convex ~~lens~~ -lenses in contact for an Eye-glass.

2 equal double convex lenses joined; their focus, & serves for an Eye-lens to a Telescope

A Rule for finding the Apertures, Focal Distance of Eye-lenses, & Magnifying Power of Telescopes.

V. Rowning's Philosophy part III. p. 177. And N.° 4. of Philos. Trans. or Vol. I. p. 191. of Lowthorp's Abridgment
The same Rule is in Smith's Optics Vol. I. p. 143. Art. 355.

Ratio of the focal lengths in double convex lenses to the Radius of their Spheres.

Light thought to decrease as the Cubes of the Distances and not as the Squares.

But If the Quadrant should be already graduated the point 0, or 45 degrees, must be found as above and the distance each falls from those pcet upon the Quadrant must be allowed for in every observation. Bion

"Honoratus Fabri in his Synopsis Optica, says, That Eustachius Divini, a famous Roman Optic-glass maker, made the Eye-Lens of his Telescope to consist of two equal, narrow plano-convex lenses, touching one anothers convexities in the axis, and so placed, that the center of the plano-convex-lens next to the object lens, was in the Focus of the object lens; by which means the Rays that came parallel from the object, would fall parallel upon the Eye: and says Fabri, some of the advantages of this Telescope are, that the colours of the rain-bow are excluded from it. The Angle of the Sight augmented. A greater field is taken in at one view. The Object appears more lively and bright. Lastly he would have water included in the vacuity between the concavities of the two touching plano-convex-eye-lenses. See much more of this in 46 Props. of Fabri's Optics." Stone's Transl. of Bion Append. p. 280.

"If two equal lenses be joined together so as to touch, the Focus will be removed to half the Distance of one of them"; these with a proper charge do well for an Eye-glass. Stone's tr. of Bion Appendix p. 280.

"Multiply the Number of Feet in the Focal distance of the object lens by ,3, and the Square Root of the product will give the Diameter of the Aperture (for the object Glass) in Inches and Decimal parts: and the same augmented by a tenth Part of itself, will be the focal distance of the Eye-lens; and the Apparent Breadths of the objects are as the Diameter of the apertures. Ex. gr. If the focal Distance of the object lens be 30 Feet it will thence be found that the Diameter of the Aperture of the object lens will be 3 inches. The focal Distance of the ocular lens 3,3 and the Proportion of magnifying considered as to the Diameter in this Telescope to One of an Object lens of one foot focus is as 109 to 20." Bion's Appendix p. 281. Also Smith's Optics Vol. I p. 143. Art. 355. {From the given Magnifying power of 109 to 20 I find that the Aperture of the Eye glass = ,35 of an Inch.}

Mr. Hugens says the focal Distance of all double convex lenses are in proportion to the Radius of the Spherical Surface as 11 to 12. Bion Append. p. 282. V. Simpson's Algebra 2d Ed. Cor. 2. p. 314. Also No. 205 of Philos. Trans. Or Vol. I. p. 183 of Lowthorp's abridgment.

"That Light descreases as the Square of the Distance, I am doubtful of, and have been so many years; there is no proof of it by acutual Experiment as I know: indeed it has been long made out by Theory to be so; but the practical Proof of these things is best, and most to be relied upon; and I have often thought, that Light in some Cases, as well as Heat, may decrease, rather as the Cubes of the Distances, than as the Squares." Ed. Stone, in Bion, App. p. 288.

45)

The Chord of 1° adapted to several Radii for the making a Quadrant

No electric Fire without Air.

If the Arch ~~[illegible]~~ of 1.° be — N.B. [illegible]

Inches		Inches
,1	The Radius of the Quadrant will be	5,729578
,2		11,459156
,3		17,188734
,4		22,918312
,5		28,647890
,6		34,377468
,7		40,107046
,8		45,836624
,9		51,566202
1,		57,29578
1,5		85,94367
2,		114,59156
2,5		143,23945

If the Chord of 1° be

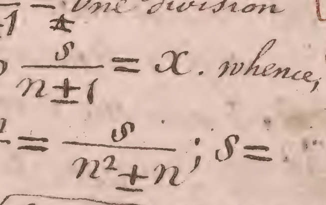
,1	The Radius of the Quadrant will be	5,72965
,2		11,45930
,3		17,18895
,4		22,91860
,5		28,64825
,6		34,37790
,7		40,10755
,8		45,83720
,9		51,36685
1,		57,29650
1,5		85,94475
2,		114,593..
2,5		143,24125

Fire goes from the Body Electrified; and acts according to the solid particles and not the surface of Matter.

Densest bodies contain most Fire, which is confined only by Air; thence the Hutchinsonian cause of Attraction of Cohesion. V. p. 48.

Any Space, its N.° of Divisions, & a subdivision by a Nonius; any two being given to find the third.

Let S be = any space AB, n = number of divisions in it, and x = one of the subdivisions which S or the space AB is required to be divided into by a Nonius CD; then $\frac{S}{n}$ = AB = one division of S; and $\frac{S}{n\pm1}$ = one division upon the Nonius CD; $\therefore \frac{S}{n} \backsim \frac{S}{n\pm1} = x$. whence, by reduction, $x = \frac{\overline{Sn \pm S} \backsim Sn}{n^2 \pm n} = \frac{S}{n^2 \pm n}$; $S = \overline{n^2 \pm n} \times x$; and $n = \sqrt{\frac{S}{x} \pm \frac{1}{4}} \mp \frac{1}{2}$. Q.E.F. V. page. 41.



Subdivisions of a Nonius

Each degree of the limb AB, divided into 3 equal parts, each will be 20'. then 19 of these laid upon the index CD, and divided into 20 equal parts, each of these will be 19 – Now the distance of these 19 parts upon the index CD, then 1' more either added or taken away, in the former case as many times 3" must be subtracted, or in the latter added, as the coincident divisions of the Nonius points out to be added to the last 20'.

Various Methods of obtaining a true MERIDIAN LINE.

Sir Christopher Wren's Contrivance (in the Philosop. Trans. N.° 291. Vol. IV. p. 464. of Jones's Abridg.t) is thus,

At one end of a ruler, erect a sight, to see the pole star, &c. thro'. At the other end set up two circles of small wire, one within the other; the diameter of the innermost, equal to the double tangent of the distance of the pole-star from the pole, the distance of the sight being radius; and the diameter of the outermost circle, Continued on p. 47.

W. J. put a wire into a receiver, thro a Collar of leathers, wherein a vessel of water was placed; made a communication from the top of the wire and the bar of an electrical machine, and fixing the inclosed or sharp end of the wire about one inch and an half above the surface of the water, he put the electrical machine in motion, when we observed the point to blow pretty hard against the water and made a considerable dint or cavity in the surface. Then was the receiver exhausted & the Machine again put in motion, when that effect of blowing & dinting was taken entirely away, even when the wire almost touched the surface of the water. - - - - Again, fixing a large plain surface of brass upon the end of the wire in the receiver and substituting a plate of Bran for the water, the bran had a very rapid ~~motion~~ double motion from and to the plate & brass; but when the receiver was exhausted, there was no motion of the Bran, not even when the brass almost touched it. Hence electrical Fire, like all others, cannot subsist without Air. - - By taking away the bran, exhausting the receiver afresh, darkening the Room, and putting the machine in motion, the fire, without any doubt, appeared to come from the end of the Wire to the brass wherein the receiver stood at the distance of 5 Inches and all distances under. Whence it seems to have its motion from the electrified body to the non-electrified. W. J. Under the same circumstance it came out of the point diverging and entered the water without any visible impression upon the surface, whereby the Air seems to act upon points different from what it does on surfaces.

From these experiments Fire, Heat or Light acts according to the solidity of matter, and not as the Surfaces, and the denser a body is, the more fire it contains; because there is nothing that can press upon, or keep Fire in bodies but air, as is evident by electrifying a wire let thro' a collar of leather into an exhausted receiver; for then it will diverge downwards from the wire to the plate, upon which the receiver stands, very freely and at a great distance: if a piece of Gold, the densest of all Bodies, be fastened to the end of the wire it will rather augment than stop the Fire, but let in the air and no fire can be drawn from the wire at so great a distance as before; therefore fire is confined by Air and that only. Now then, in densest bodies the interstices contain the finest & rarest air, therefore Fire will more easily enter these interstices than others in a rarer body containing a denser Air; (but how this is in fluids I can't say, because the densest fluid is supposed to be the coldest tho' fullest of light) so whenever two different substances come within a certain degree of each other, they take off the pressure of the air from each other on the approaching sides, and so the incumbent air pressing more strongly on the opposite sides cause these two bodies to come together. And (I think) the denser body, containing most fire, will act more strongly and cause the lighter to stick to the heavier, and not the heavier to the lighter

W. J.

equal to the double tangent of the distance of the next star to the pole-Star, from the pole. The Instrument thus prepared, look thro' the sight, & bring the two circles to the two stars, whose distances from the pole they represent; a Line passing through y^e sight and center of the circles, is the elevation of the pole: and two plumb-lines hung up, one over the sight, the other over the center of the 2 circles, will exactly lye in the meridian of the Place.

No Elasticity of the Air

Several methods of mine to find a true Meridian.

1st. With the Pole ✱ & ~~Alioth~~ having the same R^t. A.

V. Prob. on p. 122.

First way. As the motion of the north pole Star is very slow and that of Alioth in the great bear's tail pretty swift, these two are very proper for the purpose, and suppos-ing them to have exactly the same or 180° difference of Right Ascension, (which they had in the ~~year~~ middle of the Year 1760) then two plumb lines cutting each other and ~~also~~ both these stars at the same instant of time will be in the Meridian. As Alioth is visible upon the meridian, under the pole ~~from~~, in these Northern Latitudes of England, from about the 13th of December to the 16th of January N. S. (but the Globe, at 12° depression of the sun, makes it from the 1st of December to the 10th of January.) V. prob. on p. 122. This observation may be made in a clear night during all that time.

How caused.

Of Matter, Electric per se, & non electric

Difficulty of Not having the same R. A. removed.

~~But should they not have the same Right Ascension or 180° difference which is most likely to be the case~~ Since the R^t. Ascension ~~that~~ of the Pole star has now overtaken that of Alioth, and the excess of its increase ~~of the former~~ above that of ~~the latter~~ Alioth will continue a great number of Ages to come, they will not have the same Right Ascension or 180° difference; therefore it remains to find how far the plane of the two lines are from the Meridian: to do which,

They will not mix together, thence conjectured what Attraction of Cohesion is. V. p. 46.

V. Scholia on p. 113.

in Fig. 34. Z is the Zenith, P the North pole, ZPE the meridian, GAD, the path described by the pole Star, EBF that by Alioth, and ZAB, the plane of the two plumb lines; then, AP = 1°. 56'. 48" (in 1765) the Co-declin. of the pole Star, BP = 32°. 43'. 30", co-declin. of Alioth, and ∠APB = 179°. 50'. 23½" the difference of their Right Ascensions. ~~[illegible]~~ ~~[illegible]~~ let fall the perpendicular AC upon BP produced; then p spherics, making ∠APC Middle part, As Rad. : Cos. APC (= Suppliment of APB) :: Tang. AP : Tang. CP; then BP + CP = BC: And As S. BC : S. PC ::

Attraction of Cohesion, no essential property of Matter.

Cause thereof.

Continued on p. 49.

There is no essential power, whereby the air springs or moves itself, and termed Elasticity of the Air; and to give it this property is denying that powerful Agent which GOD created to perform the same office, and amounts to nothing less than denying the Works of GOD the Creator. Not one single instance was, or ever will be produced in favour of this absurd Newtonian compelling Force in each particle of Air, which they say produces this elasticity; but what is meant by a repelling force is entirely unknown to them as much as to the most illiterate, and their explanation of it is, That it is a Force whereby bodies may be said to be repelled; a fine explanation upon my word; but the misfortune is, it happens to be only in its own Terms, yet I think we ought to remain contented that it is not explained by terms more obscure than itself, if possible, as they often do.— — but to return— The Air is expanded by heat and condensed by cold, i.e. a less degree of heat; thus by heating the Air plus and minus beyond its natural state it may be reduced to any degree of rarifaction or condensation it is capable of; therefore the medium of these, its natural state, must undoubtedly depend upon the degree of heat it then is impregnated with: so the elasticity is occasioned by the Agent of Heat and not to move itself. W. J.

There seems to be something wonderful in the relation of an electric per se and non electric substances. The former are all artificial, except amber, and the latter Natural substances: Likewise those fluids which will not stop electricity will only dissolve ~~bodies~~ non electric bodies; as, mercury only will dissolve Gold, Silver, &c. water, earthy substances, &c. Moreover, those fluids which stop electricity, as Oil, will not mix with those that carry it off, as water, &c. whence the different degrees or a different disposition of the Electric matter in bodies, which is elementary heat, seems to perform what the Newtonians call Attraction of Cohesion. W. J.

W. J. cut a bit of spunge in a globular form and tied it to a wire, let thro' a collar of leather into a receiver, where stood a vessel of water; then he exhausted the receiver and let down the Spunge into the water placed in vacuo, to drink in as much as it would, then carefully taking it out, the Spunge thread & water suck'd in, together, weighed 168 Gr. These dipped in the same water in open air weighed 188 Gr. and thence was carefully tied to the end of the wire, put into the receiver, and the receiver being exhausted, there drop'd water from the bottom until it became exactly of the same weight as before, when dipped in vacuo. The weight of the thread was 2 Gr. & of the Spunge 18 Gr. when throughly dry.— Hence what becomes of attraction of Cohesion, and what is it that keeps the particles of bodies together, this experit. shews ~~[illegible]~~ that, part is the pressure of the ~~air~~ circumambient Air and the other is that of Light or Heat.

Tang. APB : Tang. PBA. — The difference between the time of the Observation and the R. A. of the N. pole * gives the ∠ZPA, to wh. add ∠APB gives the ∠ZPB. In the Δ ZPB; ∠ZPB, ∠PBZ, and PB are known, to find ∠PZB, the declination of the plane from the Meridian: let fall the perpendicular PI upon ZB; ~~[illegible]~~ then, Making PB middle part, Rad. : Tang. PBI :: Cos. PB : Cotang. BPI; and ZPB − BPI = ZPI; then S. BPI : S. IPZ :: Cos. ZBP : Cos. BZP, the Deviation of the plane formed by the two lines from the Meridian, which will be East or West according as the Time of observation is less or greater than the R. A. of the Pole star.

Hutchinsonian account, & cause of Gravity

By this one single observation the Latitude of the place is likewise had; for S. PZB : S. PB :: S. PBZ : S. PZ, the CoLat. Or rather thus, Rad. : Cotang. PZI :: Cotang. IPZ : Cos. ZP = Compl. of the Lat. of the place.

The accurate Time of Obs.^{n} an obstacle.

As the obtaining the true Time of observation is a great obstacle to this method, I should presume it the better way to get the Latitude of the place first; thus, set up any plane ~~[illegible]~~ at the most convenient angle with the horizon according to the season, place a sight so as to view the North pole Star in the plane, and mark the place; about 12 hours after watch when the Star comes again in that plane & mark the place as before; then find the Altitude of those two places marked upon the plane above that of the sight, by measuring, as shewn on p. Half the Sum of these two Altitudes will be the Latitude required; for the refraction is at that Altitude almost inconsiderable.

To find the Latitude of a place,

Mercury standing 70 inches in a Tube accounted for.

The ~~Latit~~ Latitude thus had, & ∠PBZ as above, say, S. ZP (= CoLat.) : S. ∠PBZ :: S. PB : S. ∠PZB, the deviation, as before. But by the bye, in thus finding the Lat. the Sight and middle point between the two marks upon the plane will be in the meridian & gives the very thing sought for; which may be called

and thereby remove the obstacle: ~~[illegible]~~ which also finds a Meridian.

Newton & his followers contradict each other in accounting for it.

Continued on p. 51.

If any two fluids, differing in their specific gravities, be put into a vessel, the lighter will make way for the heavier and stand uppermost and the heavier will rest at bottom; as linseed Oil, put into a vessel of water, will rest at top & the water at bottom: Water put into a vessel of the same Oil, it will make way for the water and both rest in the same situation as before: Mercury, put into a vessel of water, will instantly sink & possess the lowest place, and, at the same time, the water will rise & give place to it: Suppose Water put into a vessel of mercury with a hole at the bottom, the water would remain at top, & all the mercury would ran entirely off before any water (suppose it to fill the hole all the time), if possible; Again let a tube, hermatically sealed at bottom, be fill'd, one half of the whole length with water and the other with Spirits of wine; the water will immediately subside, and fill half the length with pure water and the other, or upper half with the risen Spirits of wine; &c. &c. Hence, if a body falls in a plenum there must be a lighter rise to make room for it; also, if a body rises in a plenum, there must be an heavier pressing into its place; for if it were otherwise, the body, in the first case, could not fall, nor rise in the second case, because there would be no room for them to change places.

Now it is proved past all doubt that there is a PLENUM throughout all Nature and the subtlist medium or fluid of Light is continually rising, therefore it necessarily follows, as well from the laws of Hydrostatics, as from above, and the similarity of all Fluids, that there must be either some body or fluid continually pressing against this Light to take its place: Is not this, or at least something like it, the Cause and Operation of that effect the Newtonians call Gravity? From hence may be assigned the cause, why mercury will stand at the height of 70 inches in a Tube V. Newton's Optics, p. 365. for mercury, being a very fine and dense fluid, will not admit air sufficient to keep the inclosed fire or light in action, much less to put it out of a state of rest into that of action; so the fire or light remaining quiescent in the mercury, no Air or other substance can press in, to give motion, from what has been asserted above: but if the tube be shaken or jarred with the finger, the inclosed particles of light are put into an undulatory motion, and since this light is the finest, subtlist & rarest fluid or medium it will consequently ascend and the fluid of air will take its place, and thereby a motion ensues, and the mercury immediately subsides & rests at the height of the Barometer [this, to the best of my remembrance, is the manner W. J. accounted for it, tho' it is obscure and unsatisfactory to me now.] S^r Isaac Newton says, it is caused by a strong attraction seated in the Glass Tube itself; but his followers, as Rowning part II. p. 72. say, that the mercury's falling about an immerged Capillary Tube is because the Glass Repells the Mercury; a fine contradiction in plain Terms, making the Glass to be endued with two contrary powers, for the self same effect. W. J.

The Second Way, as it is applicable to *Alioth* or any other Star; and, if the plane be nearly parallel to the horizon, Refraction will not affect the observation, with respect to the meridian; ~~and~~ the only objections I have to this method, at present ~~are~~ that it cannot be performed in the Summer season, when a star ~~can~~ is not visible 12 hours. and secondly, that plane passing through the erected plane & sight requires a position of passing thro' the very pole, or bisecting the path of the Star, which is presupposing the very thing sought for. & is as great an obstacle as the Time foregoing. This likewise is the case with finding the Lat. by the method just described. This is remedied by having the sight to move up and down vertically.

almost insuperable objections to finding a Merid. & the Lat. by the Method just laid down.

Third Way; ~~make choice of any two known Stars, having nearly the same Right Ascension or 180° difference of Right Ascension, on the same side and near relative motion as swift as swift as possible, for observing when both come at the same instant in the plane of two plumb lines: Then having the Latitude of the place, the deviation of those lines from the Merid. may be thus found. In fig. 3A.~~

fix upon any two known stars, which have about 180° difference of Right Ascension; their Declinations North, but ~~less~~ greater than the Latitude of the place, yet as near the zenith as can well be observed, that their relative motions may be as swift as possible. Observe when both come, at the same instant of time, in the plane of two plumb lines or rather a sight and a plumb line: Then having the latitude of the place, the deviation of those lines from the meridian may be thus found.

In fig. 34. GAD, represents the path of the North pole Star round the pole P, and EBF that of *Alioth* in the great bear: AP, the Co Decl.n of the pole Star; BP, that of *Alioth*, and their included Angle APB = the difference of their Right Ascensions; and ZAB, the plane of the Sight and plumb line. Whence by the operations repeated on p. 47 & 49. And from the Right Ascensions & Declinat.ns given on p. 19. I have found the ~~the~~ plane of the Sight and plumb-line passing through these two Stars, when *Alioth* is below the pole, declines from

The *vis inertiæ* is a consequence of Gravity otherwise 3 forces must be in every moving body.

Fluids cannot give motion & resistance in the same body at the same time

Light gives no resistance to Pendulums, as Sr I. *Newton* has made it. *Principia*. p.

Light may presses unequally in vacuo.

The water mix'd with air adds to the weight of salt of tartar. these seperated again by distillation.

The VIS INETIÆ of matter is only a consequence of Gravity; for if any motion be given to a body it is only destroying the action of Gravity upon it; as a stone drawn along the ground overcomes the action or gravity that pins it to the ground, and always endeavours to keep the body in the present state. The vis inertiæ of matter cannot be different from gravity, because it conspires with all its Laws; if it were different, then by giving a body motion the vis inertiæ will act different ~~for~~ and in different directions, at sometime, from that of Gravity, and so there cannot be less than three forces in all moving bodies. W. J.

There is no resistance of the air in the motion of a wind-mill, a ship under sail meets with no resistance from the wind; because the wind is the cause of both these motions; and a Cork put into a stream of water, running swiftly down a channel, will be carried along without meeting with any resistance from the water, because the water is the cause of its motion (and a fluid both to give & resist the motion of the same body at the same time is an absurdity) in this manner the fluid of Light imping upon a pendulum in motion tends to pin or keep it to the middle of the arch of vibration, or perpendicular to the earth's surface; because the rays of light (the cause of gravity) issue from the sun & strike the earth perpendi=cular to its surface in every part: Therefore this medium or fluid is the cause of the pendulum's continuing in motion, so cannot resist it at the same time (as above) tho' in two different editions of the Principia of Sr. J. Newton, he adopts this for his subtle fluid, first, to give no resistance to bodies in motion, but in another edition the very same experiment is brought to shew that it does resist motion and so it remains with all the Newtonians to this day. W. J.

There may be an inequality of pressure upon bodies in an exhausted receiver, because, from the prismatic Colours, it is evident light is in different conditions, and that the red making rays are constituted of the very smallest particles, & those of the violet of the very largest, and particular bodies will receive only one particular sort of rays, and that of the finer sort (exclusive of those bodies that are transparent, which admit all the rays, so will be of the same colour as before passing the body) and those of the coarser press upon the surface with a much greater force than the Air can do. W. J.

The ingenious and great Dr. Boerhaave in making oleum tartar per deliquium found the dry mixed salt, in open air, to spontaneously dissolve by water, and encrease much in weight, even to three times the original weight of salt imploy'd, and to obtain this water seperate, he distilled the oleum tartari per deliquium to dryness. then remarks that this water performs the solution in a different manner from common water, because being

the North ~~[illegible]~~ Eastward, but, when Alioth is above the pole, ~~[illegible]~~ Westward, in the

These N.os have been corroborated, yet in the beginning of the year 1764 in Lat 52°.40', the declin is 50" from the N. Eastw.

Years	Lat. 51°N.	Lat. 52°N.	Lat. 53°N.	Lat 50N.	Lat 54N
1765	0°. 0'. 29½"	0°. 0'. 30¼"	0°. 0'. 31"	0'. 29	0'. 31¾
1837	~~[illegible]~~ 0. 2. 23.	~~[illegible]~~ 0. 2. 26¼	~~[illegible]~~ 0. 2. 29½	~~[illegible]~~ 2. 19¾	~~[illegible]~~ 2. 33½

Where by it appears that if the Latitude of the place be known to the exactness of a degree only, the declination of the plane will hence be known to a second of a degree in the Year 1765 & for many years after. & I think to get a Meridian within a Second of the truth is as near as can ~~possibly~~ be wished, or even ~~[illegible]~~ possibly obtained by any method whatsoever. — As the North pole Star ~~[illegible]~~ moves by the line very slow, One of a less Declination, or greater distance from the pole, would be more proper; therefore Capella under the pole and a Star of the 3rd Mag. in Draco, about 0°.0'.0" ♈ of Long. & 85° of North Lat. are more commodious, if not the best: Also Dubbe in the great Bear, Upper pointer, ~~[illegible]~~ Alioth, below the pole, and One of the 3rd Mag. in the left thigh of Cepheus, One of the 3d Mag. in the Right shoulder of Cepheus, The heart of Cassiopeia of the 3d Mag. above the pole, are likewise very proper.

Water makes the greatest part of common Air. V. p. 8 & 10 & 56.

but alters not its elasticity. No Air without water.

Capella, also appears upon the meridian below the elevated pole from March 24th to June 30th by the Globe.

A General Rule to find the declin. of the plane.

To determine generall which way the plane of those lines decline, observe.

If the Rt. Ascen. of the Star under the pole exceed that above the pole by more than 180° the Declination is West: but if it exceeds it by less than 180° the declin. is East.

If the Rt. Ascen. of the star under the pole be less than that above the pole by more than 180° the declin. is E.; but if by less than 180° the declin. is W.

Barometer, inclosed in a bladder, alters not, by rarifying or condensing the Air within.

The observations in this third method, may be made at all seasons, and upon any Stars above the horizon, thus

Stars.	Magnitude	Beginning of the year 1783 R. A.	Declination	Distance from the meridian of a vertical circle passing through each pair of Stars in north Latitude Lat 50°	Lat. 51°	Lat. 52°	L. 52°.10'	Lat. 53°	Lat. 54°	Lat. 55°
α Urs. Minor. N. P. ✱	2,3	0. 49. 11	88°. 8'. 50",0 N.	0°. 3'. 15"	0°. 3'. 20".	0°. 3'. 24"	0°. 3'. 25"	0°. 3'. 29"	0°. 3'. 34"	0°. 3'. 39"
ε Urs. Maj. Alioth	2	12. 44. 25	57. 8. 32 N.	Westward when Alioth is below the pole, & Eastward when above it.						
α Orionis	1	5. 43. 26	7. 21. 3 N.	0. 3. 21.	0. 3. 25	0. 3. 30	0. 3. 30½	0. 3. 35	0. 3. 40	0. 3. 45
β Columbæ	3	5. 43. 20	35. 51. 49 S.	Westward.						
β Caniculæ	3	7. 15. 23	8. 49. 49 N.	0. 17. 43	0. 18. 6	0. 18. 30	0. 18. 34	0. 18. 56	0. 19. 23	0. 19. 52
η Canis	2	7. 15. 31	28. 53. 30 S.	Eastward.						
ι Centauri	3	13. [illegible] 28	35. 24. 10 S.	4. 10. 2	4. 15. 24	4. 21. 2	4. 22. 3	4. 27. 4	4. 33. 29	4. 40. 16
ζ Virginis	3	13. 23. 10	0. 31. 8 N.	Westward.						

successive and slow, it only dissolves that pure ~~part~~ of the alkaline salt, which is most soluble and less earthy and cannot be done otherwise: hence by repeating it, the whole salt may be converted into earth, and a volatile substance, that does not appear to the senses. This and like considerations "led him to discover that the air contained in a three-pint-bottle, might hold water enough to moisten an ounce of salt of tartar, and increase its weight; and upon repeating the experiment, I found that the water (here mixed with the air) being, perhaps, 850 times heavier than common air, must make up the largest part of the weight of this portion of air; for, if the 850th part of common air be water, the whole weight of the air must be owing to the water alone; whilst the other parts add little or nothing to the weight, or perhaps do not gravitate at all. M. Deventer the famous writer upon midwifery, assured me he had made the same observation." Shaw's Translation of Boerhaave's Chemistry Vol. I. p. 100. Art. 11, & 15.

p. 101. This experiment did not add any thing elastic to the oil of tartar per deliquium and the air's elasticity remained as perfect and strong as at first. Also p. 103 & 104. "There is no air without water, even on the tops of the highest mountains."

Inclose a Barometer in a pliant bladder, with no more air than will remain after squeezing it well together with the hand; apply a strong fire to it (taking care to keep it moist, lest it should shrink) and no manner of alteration ~~[illegible]~~, in the rising or falling of the Barometer will ensue, because the action or pressure of the air ~~[illegible]~~ upon the bladder without, ~~is~~ was a counterballance to that within, at first, (for they were both of the same state and each contained an equal quantity of fire) now the fire rarifies the air within, makes a less quantity of air in a given space, but more active, and so what is lost in density is exactly made up by the action or force of the fire, for the action or pressure without resists the swelling of the bladder, (in this experiment) and a continual equilibrium is preserved between them, if at any time they should not be in equilibro, then by the laws of hydrostatics, the nature of all fluids, and the supposition of the bladder being perfectly pliant, it would either shrink less or swell more until they were in equilibro. — If the bladder were full blown, the case would remain the same, & be just as if the bladder was Glass, or other unpliant substance.

If the flaccid bladder be put under a receiver, upon exhausting the air, it will swell prodigiously and the mercury in the inclosed barometer will sink until the bladder is done swelling; the reason is because the outward pressure is removed and the air within the bladder takes up a greater space than before, and consequently is more rare & occasions the barometer to fall: if only one half of the receiver be exhausted and then a strong fire applied, the same effect will ensue, as if the receiver had been more exhausted proportionably to the heat applied. W. J.

A Barometer & Thermometer both inclosed in a veſsel & put into an exhausted receiver & rise with Heat

Air converted into Fire.

Barometer will not measure height of mountains.

No pure Air, so all Experiments depending upon it as such are false.

All Thermometers should be made when the Barometer stands at 30 inches.

Both a barometer and thermometer inclosed in a glass vessel, or the bladder above, put under a receiver, exhaust the air & apply a strong fire, the heat whereof will be measured by the thermometer; the ~~in proportion to the heat applied~~ barometer will rise the same, in proportion to the heat applied, as if the close vessel were heated in open air; because the inclosed air is of the same temperature with the atmosphere, containing (suppose) 55 degrees of fire; by making the inclosed thermometer rise to 110, there will be added 55 degrees of action or force, and the same quantity of air occupying the same space as before, consequently a greater pressure will be upon the surface of the cistern within, which is the only cause of the barometer's rising. ~~Let~~ every thing remaind thus till perfectly cold; then the inclosed Barometer stood lower than in open air at the time of being inclosed, but the thermometer at the same height; thence it is evident that some of the inclosed air was converted into fire and pierced the pores of the vessel. W. J. made this experiment to shew how absurd it is for the <u>Newtonians</u> to pretend to measure the pressure of the air by its quantity, since that is not the same for two minutes together; for the best thermometers will rise & fall every moment of time, and therefore has continually a different degree of Fire contained in it. W. J.

I am not at all certain of this whole experiment, though it was tried in my presence, & therefore ought to be repeated before any dependance can be relied on.

To measure the height of mountains by the fall of the mercury in the barometer is very erroneous; for the air may be so intermixed and compounded with <u>water</u> (as it really is, see p. 54.) as not to be perceived in any experiment, there is also a sulphureous and nitrous or acid quality in it, as appears by its rusting of Iron, Copper, &c. There is likewise a particular height to which vapours cannot rise, much higher than the <u>Pico Tenerif</u>, & so out of the reach of any experimentalist: all experiments hitherto about air, suppose the atmosphere to be pure air, but it is not, because watery, acid, and nitrious vapours are continually rising from the earth, and the more rare they are the higher they ascend; thence to argue by analogy from experiments made upon that supposition must be false, because the gross atmosphere is not analogous to pure air. Upon this consideration many secrets of the barometer depend. W. J.

The scales of a thermometer will be unequal, which are made under unequal heights of the barometer, therefore 30 inches for the height of the barometer is and should always be the standard for making Thermometers, otherwise the motion of no two can be compared, because they will never stand at the same divisions of both, with the same heat; for water will require a much greater heat to boil it, when the Barometer stands very high, than when it stands low; because the pressure of the atmosphere upon the surface of the water is proportionable to the

height

Astronomical Table for variation of Compass

"They write from Scotland, that the Rev. Mr. Dingwall, an eminent Mathematician, has lately invented a set of Astronomical Tables, calculated for discovering the variation of the Compass in any latitude without having recourse to the old method of observing either by azimuth or amplitude."

Cambridge Chronicle for September 7th 1765.

Magnetism thought to be fire.

His Majesty's WATCH, shews time to a 300th pt. of a Minute

"The new watch made for his Majesty by Mr. Arnold, shews the time to a 300th part of a minute, winds up by one push of the pendent, and continues going during that time; all the holes in the watch are jeweled, and it is allowed by judges to be the compleatest piece of workmanship in this kingdom." Do. Chronicle for Do.

Soft iron receives it soonest, but retains it the least time.

Cause of Thunder.

The fire, made apparent in electrical experiments, pervades and adheres to most bodies; while it flies, and cannot be brought to mix with some particular bodies; it flies & shuns air, but pervades water more intimately than almost any other body: and it not only pervades, but also surrounds & covers them to a certain distance from their superficies, in proportion to the state of its activity, which is increased by heat: moreover, when it is artificially or accidently protruded upon any body beyond its natural affection, it will fly off to the next approaching body, which is not so much impregnated with this fire; and when it departs in any considerable quantity, it makes a great noise or crack: Now, to shew, that this fire is the real cause of thunder, we need only consider it attending every vessel of humid vapour rising into the atmosphere, and covering its superficies to a certain depth; which I think it must certainly do. (How far this fire is the cause of vapours ascending is left for a future number) Now, in the collision to form the drops, descending much larger than the vesicles, in which it ascended, we must consider what becomes of our fire; for the surface of these larger drops increasing only as the squares, but their solids as the cubes of their diameters, the fire, which surrounded the superficies of the vesicles, must be protruded to a much greater distance from the superficies of the larger drops, & by that means made more in proportion to the larger drops, than its natural affection would have made it join them with; &, consequently, rendred more apt to fly off to the next approaching or approached body, not so fully impregnated by this fire. The constant seat of thunder is in those clouds, which are most compact of humid vapour, and which descend in the heaviest showers, and that generally in warm weather, when the adjacent atmosphere is serene; so that the humid vapours are almost all collected into this chain of clouds; where, according to the compaction, there will be a body of this fire collected, and ready to fly off, sufficient to perform the greatest effects of thunder. Now some of these clouds coalescing in their descent, and the drops increasing in their magnitude, there is a vast body of this fire collected more than what would naturally adhere to those drops and their surfaces; which being rendered more active in its vibrations, by the heat of the lower part of the atmosphere, the sphere of its affections (pardon the word, ~~for I know~~ for I have no other) is also increased in proportion to the body of fire, which enables it to fly off to clouds, no so much impregnated, at a considerable distance, with that violent crack so much taken notice

The condition of the Earth & Clouds at the time of Thunder.

Seasons periodical. Why an Hot or Dry summer is succeeded by a Cold or Wet winter.

(continued on p. 59.)

height of the barometer, and the fire must act with a stronger force to lift up the water with a greater pressure than with a less, for the same reason Urine lukewarm will boil under an exhausted receiver. W. J.

Magnetism is owing to fire; for Mr Franklin says, that with a very strong shock of electricity he has given magnetism to iron, and it is past all doubt that electrical effluvia is fire, for it has great similarity with lightening. we have also often heard of lightening destroying the Mariner's magnet, and even sometimes its ~~the~~ poles ~~of the magnet~~ are turned quite round, or altered to the direction the lightening proceeded in; or the effect of it has been augmented or diminished: farther, by heating a bar of iron red hot and quenching it with the ends North and South, it will have some degree of Magnetism. Moreover, in Nova Zembla the needles were so frozen as to lose their magnetism, and would have it again by holding it to the fire but no longer. - Soft iron having the least pressure & containing least fire will receive magnetism easiest but retain it the shortest time. harder iron having a greater pressure and more fire receives magnetism not so easy, but will keep it longer. Case-hardened iron having the greatest pressure and most fire, will not receive it at all. W. J.

JOB XXVIII. 26 When he (GOD) made a decree for the rain, and away for the lightning of the thunder: at the time of thunder and lightning the earth is supposed to be full of electrical matter, like the electrical tube or bar, and the clouds being nonelectric bodies, like those applied to the tube or bar, they, by approaching the earth, discharge fire with a report; as is represented in miniature by electricity: and as the electrical fire proceeds from a non-electrical body to the bar, v. p. 46. that way wherein it meets with least resistance (whether it be the shortest or not) so the fire proceeds from the clouds towards the earth, through the rarest and driest part of the air, because it then meets with the least resistance, and has various turnings & windings in its progress, as is evident from the best Thermometer's being in a continual flux for every moment of Time. W. J.

The sum of the Heats in summer and sum of Coldness in Winter are more moderate and more severe periodically, each period including several years, tho' not always of the same Number, for at the poles the solar refraction makes their half year of sun 7 months, and the prevailing rays reflected strongly from the frozen sea including the countries between the latitude 60 and 70 (those of a greater lat. being thaw'd) a continent of ice and innumerable mountains of the same kind of Glass, must in one month produce such a thaw as will disjoin them and set them a float. This will happen about the

middle

notice of; tho' it is far from being the most wonderful of its effects, the dire influence of which we often happily escape, by this body's being dissipated by the heat of the lower atmosphere, before it comes within the sphere of its affection for bodies on the surface of the earth. There is a subsequent rumbling noise heard after the first crack or cracks of thunder, (for this fire does not all break of from one point) which has been taken notice of, and oddly accounted for; but I think it neither is nor can be more than echo's from adjacent clouds, which at this time are generally dense enough for that purpose; and the noise growing fainter in proportion to the times of its being returned I think sufficiently proves it. —— —— Where one body has been injured by thunder, and another, tho' in contact with it, has remained untouched, the latter will be found to be of that kind, which electrical fire will not join with.

I shall venture to trouble you hereafter with some farther attempts to shew, that this fire is a most considerable agent in nature. First, that the ascent of vapour and exhalation is principally owing to it, and that our atmosphere, by that means, is kept more homogeneal than is generally supposed, and fitter for respiration, vision, &c. and that clouds of heterogeneous matter are kept suspended at their usual height merely by this fire. Secondly, I shall prove, that this fire is the cause of reflexion, refraction, and inflexion of light. Thirdly, I shall endeavour to shew, that it is the cause of that secondary attraction and repulsion, which Sir Isaac Newton hast taken notice of. Lastly, I shall give some hints of the great use of this fire in animal life, and in vegetation.

From Nº LXXXIX. of the Philos. Trans. Vol. 47. for 1751 & 1752. being A letter from Mr Henry Eeles, Esq. to the Royal Society, concerning the cause of thunder. Dated from Lismore, Ireland, June 18, 1752.

This promise above is performed in Philos. Trans. Nº XXV. of Vol. 49. Part. I. for 1755. Wherein he says, that the ascent of vapour and exhalation through the air may be effected two ways; by impulse, and an alteration of their specific gravity. That it does not generally ascend by impulse he proves thus. Put boiling water into a vessel, & then empty it, & hold the vessel with the aperture downwards: the vapour, which is afterward expelled from the vessel, must be in a direction downward; but as soon as it has got a very little below the rim of the vessel, it has its direction altered, and ascends by the laws of specific gravity. The same thing may be observed in all boiling vessels, where the vapour is emitted in a direction downward; or, in cold weather, when the vapour of a man's breath may be seen, let him breath downward, and the direction of his breath will be presently altered, as in the former case. Since then vapour does ascend without any other impulse than that, which is incident on all bodies ascending by the laws of specific gravity; it is necessary to enquire, how the specific gravity of vapour is altered to cause its ascent. He next sufficiently knocks down the general solution by filling vesicles of water with rarified air: and that neither impulse, rarefaction of the air, or any formation of their parts by expansion, will do the business. — By nameless experiments to prove the property of electrical fire, (which he supposes surrounds every vesicle of water ascending, at least,) he says, it appeares, that all fumes rising from fire, whether blazing or otherwise, and all steams rising from boiling or warm waters, and from all other fluids, and the breath of man, and of all other animals, and all the effluvia thrown off by perspiration, are strongly electrified. Because, First, That desultory motion, by which it flies off from an electrified body to any number of non-electrics, which are brought within the sphere of its activity and affection, until it be equably diffused through all. Secondly, That the sphere of its activity is increased by heat. Thirdly, That this fire does not mix with air. Fourthly, That it intimately pervades water, and many other bodies, covering their superficies to a certain distance; which distance is not in proportion to the bulk of the body electrified, but in proportion to the state of activity of the electrical fluid. Fifthly, This electrical fluid readily joins with any fire; but will not mix or fly off with the fire of red-hot iron, or any other metal, which does not fume. This I have not met with in any writer, but have proved it by experiment. — I shall not undertake to determine, by what cause vapour & exhalation are detached from their masses, whether by the solar or culinary fire, or by the vibrations of the electrical fluid rendred more active by those; though I am led to think the latter: but to shew that this electrical fire or fluid is the principal cause of the ascent of vapour & exhalation, we need only prove, that it attends all vapour and exhalation, and that in such quantity, as is necessary to render them specifically lighter than the lower part of the atmosphere: which is thus proved. I extended a fine string of silk 8 feet horizontally, and from the middle suspended two pieces of such down as grows upon our turf-bogs, by two pieces of fine silk, each about 12 inches in length; and then, by rubbing a piece of sealing-wax on my waist-coat, over my side, I

Cold closes the pores of the earth, & keep vapours from rising.
Places in the same degree of latitude have not the same degree of Heat & Cold.
See p. 4.

accounted for.

continued on p. 61.

middle of April, and the polar ice being thus brought and fixed 30 degrees nearer to us than the place where it was generated, will naturally so far counteract the influence of our vernal sun that we shall not enjoy warm weather till June; nor then if a north east wind blows long together. — In autumn, when our weather would otherwise be cold, the frozen Zone between 60 and 70 Degrees having being at length dissolved, the frigid influence is suspended, and our winter is proportionally warmer as our summer had been colder.

But in some winters the ice at the pole is never dissolved, for when it happens that the atmosphere is there filled with gross humid particles, that freeze into a thick rhime, or hoary frost, a mist is generated which the solar rays cannot pierce with sufficient force to operate by reflexion from the surrounding promontories of ice; when this happens, it is likely to continue several seasons, and the Zone of ice that used to lie between 60 and 70, is then farther removed, and lies between 80 and 90, and our seasons being then free from foreign influence, will be hot and cold in proportion to our latitude at the solstices, and the weather will be in an intermediate state at the equinox. Upon these humble offered hypotheses the regularity or irregularity of our seasons depend, and the dryness or humidity, or the clearness or obscurity of the polar Atmosphere. Gents. Mag. Feb. 1756. p. 73.

In cold and frosty weather the pores of the surface of the earth are so shut up and closed that the vapours cannot rise as they do in warm weather. Dr. Woodward's Hist. of the earth.

Places which lie in the same degree of latitude have not the same degree of Heat and Cold, and of this Norway affords a more remarkable instance than any other country. On the east side, the cold is so severe that cataracts formed of the largest rivers are arrested in their course and frozen into huge fragments of ice as they fall. The spittle is no sooner out of the mouth than it is frozen into a ball, and rebounding from the ground rolls along like hail, and the effect of cold on the balls of horse-dung, newly dropt, is yet more amazing, for they move and leap upon the ground, the motion being caused, by the conflict between the sharp dense air which penetrates them from without and the warm air which is expelled from within. But the western parts, which lie in the same parallel of latitude, have temperate winters, the frost seldom continuing more than a fortnight, all the bays and lakes being open, and the air moist and cloudy. To account for this difference of season, it is remarked, that

61) p. 59. continued.

I electrified the pieces of down; and brought sundry ~~burning~~ things under them, so as to let the smoke pass in great plenty through and about them, to try whether the electrical fluid would run off with the smoke; but I had the pleasure to see that the down was but little affected by the passage of the smoke and still remained electrified." — With the same success he applied in like manner with the smoke, sundry steams from the spout of a boiling tea-kettle, his own breath; the ~~f~~ subtle effluvia thrown off by the perspiration of his hands with his fingers extended perpendicularly, and in short, all the vapours & exhalations he could think of. "I then warmed a wine-glass, and with the skirt of my coat held inside and outside the glass between my fingers and thumb: I rubbed the glass briskly about, and electrified the down, and found all experiments answer in the manner as they did with wax." which, by the bye, likewise shews that there are not two kinds of electrical fire, the one resinous and the other ~~vitr~~ vitreous; as some authors affirm. — "The electricity remaining in the electrified down after these experiments made it appear, that the smoke and steams must be either electrics, or non-electrics electrified. It was easy to suppose them non-electrics, as they arose from non-electric bodies; and the more, because the highest electrics by a discontinuity and ~~comminution~~ comminution of their parts (long before they come to be as minute as the particles of ascending vapour), become non-electrics, or conductors of electricity. For glass, resin, wax, &c. all become non-electrics, even in fusion. But to try whether the steams, &c. were non-electrics, I only bedewed the wax and glass with my breath, steams, &c. from my hand to the end of the wax and glass; and then touching the electrified down with the end of the wax or glass, I found, that the electrical fire immediately passed from the down into my hand, thro' the steams, &c. which rested upon the wax and glass. Which, I think, sufficiently proves the steams, &c. to be non-electric, and I think, that it as plainly appears, that they are all electrified while ascending, because the electrical fire in the down does not join with them in their passage through it; which otherwise it would do with them, or any non-electric not electrified."

Hence the down, plumes of feathers, or any light matter are evidently much lessened in their specific gravity by being electrified; "and that, by holding another electrified body under them, they may be driven upwards at pleasure. It is also evident, from experiment, that the more you divide the parts of such bodies, the more of their specific gravity they will lose by being electrified; and by dividing them into very minute parts, I have found, that they ascended to a considerable height after they were electrified. From hence I think it highly probable, that the exceeding small particles of vapour and exhalation may be, and are, sufficiently electrified to render them specifically lighter than the lower air; and that they do ascend by that means. And that they will ascend proportionally higher, as the surrounding fluid is proportionally greater than the particle, which is carried up." He next shews, that the ascent and descent of vapour and exhalation, attended by this fire, is the principal

Quality of the 4 winds, and why.

East & West are moderated by the earth's rotation.

Of the Circulation of the Blood, and the Union of Arteries and Veins.

Argument against Astrology.

(continued on p. 63.)

that the western side of Norway lies nearest the great ocean, and the frost is there dissolved by the watery exhalations that are perpetually mixing with the air as they rise from the sea.

Where the winter is extreme cold, the summer is hot in the same degree; of which there cannot be a stronger instance than in that barley in Norway grows up and ripens in six weeks. Gents Mag. 1755. p. 220 & 221. from Bp. Pontoppidan's natural History of Norway.

Since the north wind always blows from a cold climate, it must therefore be always cold; and the east wind from a new portion of the earth's orbit, just beginning to be heated & enlightened by the annual motion of the earth, must also be cold; the south wind from an hot climate, it must likewise be hot; and the west wind from a portion of the earths orbit, just left in great warmth, must necessarily be warm. W. J. But I should imagine, that the earth's diurnal motion will always moderate the cold of the east wind, by turning the particles last heated towards the east, from whence the wind blows: ~~Moreover~~ I should also presume, that the west wind will always be moderated with cold, by the earths diurnal motion because that part, which is but just beginning to be heated, is thereby turned towards the west, from whence the wind blows.

"The blood appears, by the microscope, to flow from the arteries to the veins immediately, which is easily seen in the webs of frogs, tails of fishes, mytuli, &c., and I doubt not, would appear so in muscles, if they were thin enough to become transparent for viewing with glasses. Therefore the arteries and veins may be considered as continued tubes, terminating in nothing; but as the arteries arise immediately from the heart, so they run to the extremities of the lungs and body, ramifying and decreasing in diameter, till they become invisible to the naked eye, and gradually become veins, which arise into trun ks, increasing in diameter till they arrive at, and open into, the heart again. So that nutrition and the secretions are carried on by minute twigs, from these continued capillary canals (i. e. where the arteries degenerate into veins) sent off to the glands, and to the parts to be nourished". Martin's Abridg.t Philos. Trans. Vol. X. p. 1137.

If there ever was any such thing as Astrology, the eastern people or Caldeans must have had it; because they were possessed of all the Knowledge in the world: if they had it with any degree of assurance or Truth, why did they not calculate the greatest

Nativity

 (p. 61. Continued.)
principal cause of all our winds, in doing which, he hopes to bring down the vapour and exalations again, but in a manner not at all satisfactory to me. He then goes on to shew, how the general phanomena of the weather and barometer arise from his System. "First, Why it generally rains in winter, while the wind is south, south-west, and westerly. Secondly, Why north-west winds are generally attended by showers in the beginning, and become more dry, as they are of longer continuance. Thirdly, Why north and north-east winds are generally dry. Fourthly, Why the east wind continues dry and dark for a considerable time together. Fifthly, Why squalls precede heavy and distinct showers; and why a calm ensues for some ~~time~~ little time after they are pass'd. Sixthly, Why storms and high winds seldom happen in a serene sky without clouds. Seventhly, Why the vapours, in warm seasons, coalesce to form those distinct dense clouds, which produce thunder and heavy showers. Eighthly, Why the barometer falls lowest in long continued rains, attended by winds; and why it rises highest in long continued fair weather; and why the intermediate changes happen. Ninthly, Of land-breezes and sea-breezes, and water spouts." To all which his principles above may be easily apply'd, ~~together with~~ and their appearing to me insufficient and inadequate for the effect, is the reason of my not pursuing him here throught all those stages,

The quantity 88 Oz at the Surface, loses in weight, at 20 Fathoms Deep.

From the Philos. Trans. Vol. 49. Part I. p. 300. for 1755.

N.° I, I. Electrical Experiments, made in pursuance of those by M.r Canton, dated Decem. 3, 1753; with Explanation by M.r Benjamin Franklin, communicated by M.r Peter Collinson, F. R. S.

Philadelphia, March 14.th 1755.

Two Serpents are emblems of the joint Actions of the Light & Spirit.

Read Dec. 18. 1755. Principles. I. Electric Atmospheres, that flow round non-electric bodies, being brought near each other, do not really mix and unite into one atmosphere, but remain seperate, and repel each other. — This is plainly seen in suspending cork balls, and other bodies electrified.

II. An electric Atmosphere not only repels another electric atmosphere, but will also repel the electric matter contained in the substance of a body approaching it; and without joining or mixing with it, force it to other parts of the body, that contained it. — This is shewn by some of the following experiments.

Air or Spirit, what.

III. Bodies electrified negatively, or deprived of their natural quantity of electricity, repel each other, (or at least appear so to do, by a mutual receding) as well as those electrified positively, or which have electric atmospheres. — This is shewn by applying the negatively charged wire of a phial to two cork balls, suspended by silk threads, and by many other experiments.

Preparation. Fix a tassel of 15 or 20 threads, 3 inches long, at one end of a tin prime conductor; (mine is about 5 feet long, and 4 inches diameter), supported by silk lines. — Let the threads be a little damp but not wet.

Experiment I. Pass an excited glass tube near the other end of the prime conductor, so as to give it some sparks, and the threads will diverge. — Because each thread, as well as the prime conductor, has acquired an elastic atmosphere, which repels, and is repelled by, the atmospheres of the other threads; if those several atmospheres would readily mix, the threads might unite, and hang in the middle of one atmosphere, common to them all.

Rub the tube afresh, and approach the prime conductor therewith, crossways, near that end, but nigh enough to give sparks; and the threads will diverge a little more.

(Continued on p. 65) Because

Nativity in the world, being that of Christ; and if the old Planets or Stars were designed by God to foretel events upon earth, why then did God create a new miraculous Star to guide the Eastern Magi, to the place of Christ; which could not be a revolving Planet, because it stood over the very place where Christ was   Again, Christ was born to give Light to this world at the very instant the natural Sun, the light of this world, was in the very depth of Darkness; for he was born at midnight, and in that year the shortest day fell on the 25.th of December, the day now celebrated for his birth. W. J.

See allso the converted men in Acts XIX. 19.

A Bag with a line and weights, amounting in the whole to 88 Oz, were weighed at the surface of the earth, at the edge of a Coal pit 20 Fathom in depth, when the line and bag of weights fixed at the bottom of the scale, wherein they before had been weighed, these 88 Oz amounted but to 87; for the opposite scale exceeded by the weight of three half-pence equal to 1 Oz. This experim.t was procured out of Cumberland by W. J. and kept by him as a great secret.

A Serpent was an Emblem of the Spirit, and likewise of the Light; two of them twisted together round a Rod, as the Caduceus of Mercury, were an emblem of the joint Actions or strugglings of the Light and Spirit, which, the Sacred penmen, in Holy writ, call ~~שחקים~~ שחקים Shekakim, Strugglers, and is referred to, under the emblem of the crooked Serpent, by Holy Job. in his XXVI. Chapter & 13.th verse.

Air or Spirit is made by the adhesion of the atoms of Heaven into lumps or grains; to this God refers in Job. XXXVIII. 37, 38. "Who numbered, and so settled the Quantity of the Æthers, and the Defluxes of air who caused them to fall down, for melting the Dust into Concretes, so that they adhere in Grains?" Bate's answer to Jennings. p. 16.

שמש, Shemesh, the Solar Light
ירח   the Lunar Light
חמה   the Heat of the Sun
חרם   Solar Fire
לבנה   the Whiteness of the Moon
הכחבים   the fluxes or light of the Stars
יום, Jom, a Day, from the Root
הום, Hōm, (Strepitus) a Noise, Stir and bustle of Works.
לילה,   a Night, from the Root   ילל

Because the atmosphere of the prime conductor is pressed by the atmosphere of the excited tube, and ~~driven~~ driven towards the end where the threads are, by which each thread acquires more atmosphere.

Withdraw the tube, and they will close as much. — They close as much, and no more, because the atmosphere of the glass tube, not having mixed with the atmosphere of the prime conductor, is withdrawn entire, having made no addition to, or diminution from, it.

A seeming Cause of the Tides.

Bring the excited tube under the tuft of threads, and they will close a little. — They close, because the atmosphere of the glass tube repels their atmospheres, and drives part of them back on the prime conductor.

Experiments upon weighing Air.

Withdraw it, and they will diverge as much. — For the portion of atmosphere, which they had lost, returns to them again.

Experiment II. Excite the glass tube, and approach the prime conductor with it, holding it across near the opposite end, to that on which the threads hang, at the distance of 5 or 6 inches. Keep it there a few ~~minutes~~ seconds, and the threads of the tassels will diverge. Withdraw it, and they will close. — They diverge, because they have received electric atmospheres from the electric matter before contained in the substance of the prime conductor; but which is now repelled and driven away, by the atmosphere of the glass tube, from the parts of the prime conductor, opposite and nearest to that atmosphere and forced out upon the surface of the prime conductor at its other end, and upon the threads hanging thereto. Were it any part of the atmosphere of the glass tube, that flowed over and along the prime conductor to the threads, and gave them atmospheres (as in the case when a spark is given to the prime conductor, from the glass tube) such part of the tube's atmosphere would have remained, and the threads continue to diverge: but they close on withdrawing the tube, because the tube takes with it all its own Atmosphere, and the electric matter, which had been driven out of the substance of the prime conductor, and formed atmospheres round the threads, is thereby permitted to return to its place.

Take a spark from the prime conductor, near the threads, when they are diverged as before, and they will close. — For by so doing you take away their atmospheres, composed of the electric matter driven out of the substance of the prime conductor, as aforesaid, by the repellency of the atmosphere of the glass tube. By taking this spark you rob the prime conductor of part of its natural quantity of the electric matter; which part so taken is not supplied by the glass tube, for when that is afterwards withdrawn, it takes with it its whole atmosphere, and leaves the prime conductor electrised negatively, as appears by the next operation.

Then withdraw the tube, and they will open again. For now the electric matter in the prime conductor, returning its equilibrium, or equal diffusion, in all parts of of its substance, and the prime conductor having lost some of its natural quantity, the threads connected with it lose part of theirs, and so are electrised negatively, and therefore repel each other, by Princle III.

Approach the prime conductor with the tube near the same place as at first, and they will close again. Because the part of their natural quantity of electric fluid, which they had lost, is now restored to them again, by the repulsion of the glass tube forcing that fluid to them from other parts of the prime conductor: so they are now again in their natural state. Withdraw it and they will open again. For what had been restored to them is now taken from them again, flowing back into the prime conductor, and leaving them once more electrised negatively.

Bring the excited tube under the threads, and they will diverge more. — Because more of their natural quantity is driven from them into the prime conductor, and thereby their negative electricity increased.

Experiment III. The prime conductor not being electrised, bring the excited tube under the tassel, and the threads will diverge. — Part of their natural quantity is thereby driven out of them into the prime conductor, and they become negatively electrised, and therefore repel each other.

Keep the tube in the same place with one hand, attempt to touch the threads with the finger of the other hand, and they will recede from the finger. (Continued on p. 67) Because

the Act of Howling, Amos V. 8. because Beasts then begin to Howl.

Job. XLI. 31. He maketh the Deep to boil like a pot; he maketh the Sea like a pot of ointment. This seems to intimate that the Cause of the Tides were like that of boiling water but just lukewarm under an exhausted receiver. V. Job. XXXVIII. 14. XXVI. 7. The earth hangeth upon nothing.

Octob.r 2nd at noon W. J. & myself weighed a Receiver 20 inches long & 4 or 5 in Diameter with a brass plate and cock cemented to the open end, all which were = ~~[illegible]~~ 1 lb Averd. or 1 lb 1 oz 15 dwt 0 gr Troy, then filling it with common water, the weight was = 3 lb Averd. or 3 lb 0 oz 4 dwt 8½ gr Troy. whence the weight of the water alone was = 2 lb Aver. or 1 lb 10 oz 9 dwt 8½ gr Troy. (i.e. by allowing 7008 Gr. Troy for 1 lb Averd.) = 24800½ Gr. the water measured 996,25884 Solid inches. Next it was emptied, well cleansed, & cooled, hung to the center ~~[illegible]~~ bottom of a Scale (which scales would easily turn with ¼ of a Gr.) nicely ballanced in the other, taken off again & the air exhausted, till the mercurial gauge stood at 28½ inches, and then weighing it again, 26 Grains was lost, but turning the Cock to let in the Air, it then weighed as before. the second trial lost 27 Gr. a third 28, a fourth 27, a fifth 27: so that 27 seems to be the mean & true number, with which the proportion of Water to Air is as 918,6 ferè to 1. but if 28 be taken, then the Ratio will be as 885,43 to 1. The same experim.t was twice repeated with the mercurial gage raised half way, or 14¼ inches; the receiver then weigh'd 11 Gr. lighter than before exhausting; but upon turning the Cock & letting in the Air, it weighed 2 Gr. heavier the first time, and 3½ the second. With ¾ of the gage = 21⅜ inches exhausted, it required 23 Gr. to be added to preserve the same weight as before exhausting, but taking away these same 23 Gr. and letting in the Air, it required 2 Gr. to be added for the same weight; With ¼ of the gage = 7⅛ inches, 5 Gr. was taken away, upon letting in the Air, it weigh'd ½ Gr. lighter than when full of air. The whole repeated will stand thus

Inches, height of the gage	Weight lost by exhausting	Weight gain'd again by letting in the Air
all = 28½	26 Gr.	26 Gr.
	27	27
	28	28
	27	27
	27	27
½ = 14¼	11	13
	11	14½
¾ = 21⅜	23	21
¼ = 7⅛	5	5½

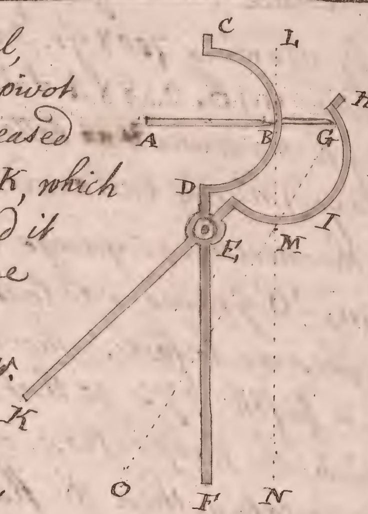
It was sometimes, tho' not always, found, that it weighed heavier immediately after letting in the Air, than it did 8 or 9 minutes after, therefore at each new weighing after letting in the Air, it remained sometime in equilibrio, before the

 p. 65. Continued

Because the finger being plunged into the atmosphere of the glass tube, as well as the threads, part of its natural quantity is driven back through the hand and body, by that atmosphere, and the finger becomes, as well as the threads, negatively electrised, and so repels, and is repelled by them. To confirm this, hold a slender light cork of cotton, two or three inches long, near a prime conductor, that is electrised by a glass globe, or tube. You will see the cotton stretch itself out towards the prime conductor. Attempt to touch it with the finger of the other hand, and it will be repelled by the finger. Approach it with a positively charged wire of a bottle, and it will fly to the wire. Bring near it a negatively charged wire of a bottle, it will recede from that wire in the same manner, that it did from the finger; which demonstrates the finger to be negatively electrised, as well as the lock of cotton so situated.

The Case with Vegetables, Animals and Fossils, at the Time of the Deluge.

In the annexed fig. let AB be a rod of metal, acting against a lever CBDEF which turns upon a pivot at E, and CBD is a semicircle; when AB is increased to G, it will drive the leaver into the position HIK, which ~~and~~ thereby describes the Angle KEF; whereas, had it acted against the strait lever LMN, it would have drove it into the position GMO, and described only the angle NMO, much less than the former. So that I think this is an improvement upon levers, especially those adapted to Pyrometers.



From whence I have derived these problems

1. When BG and DE are given what is the diameter of the circle CBD, which shall cause the angle KEF to be the greatest possible? And again,
2. What is the nature of the curve CBD, so that the ~~two~~ lever shall describe equal angles, by every equal increase of the Bar AB; or that ~~the increase of the bar and of~~ the bar AB and angle KEF shall both increase uniformly till B arrives to G.?
3. Suppose both the above cases are required; when ~~and the instead of~~ the point B, or G is a little pulley or wheel, of a given diameter, acting against the lever CBDF at B, G.?

Annual & Diurnal motions of the Earth, Summer and Winter, and Day & Night, all ceased at the Deluge.

the above given weights were taken.

Lord Bacon with his Table of Specific Gravities says, that the space which holds exactly one ounce of pure Gold will hold 1.. Pnt 3 Gr. of common water; whence by Ward's Table I find that Space to contain ,096533 of a solid inch (from the Gold).

The hardest terrestrial Solids as Marble &c. were dissolved at the Deluge; but all animal and vegetable Bodies, Bones, Teeth, Shells, Trees, Shrubs, Herbs, and even the tenderest Parts of them, such as Leaves, remained entire and altogether undissolved or unhurt; Witness the Parts of Vegetable and Animal Bodies, dug up in all Places, and on every side of the Globe, many of them fair, unaltered, and perfectly well preserved to this day. And those undissolved bodies some of them are incoperated with the substance of the dissolvable and the Strata lies as ~~a sediment~~, Sediments settled from Water. [This is an untruth] Now the Cause of the Cohesion of the Parts of Fossils was quite different from that of Vegetables and Animals, the latter are made up wholey of Fibres: and those Fibres are interwoven each with other, tyed, twisted, and complicated together; by which means the Cohesion of all the parts is maintained and preserved. But the Cohesion of the Parts of Fossils is owing to quite a different Cause. The Solidity of Fossils is undoubtedly the effect of Gravity. All sorts of these bodies are composed of Granules, only applied, and contiguous, to each other; but independant, and not anyway connected, or tyed together; (which the Parts of Vegetables and Animals are); and they are all held together merely by the Compression and Gravitation of the external Ambient, the Air, Æther, and other component Parts of the Atmosphere wherein they exist. So that nothing more was needful, for the total Dissolution of these, than the suspension of the Cause of their Solidity, I mean Gravity or the compression of the Air. This would in no wise effect the Vegetables & Animals.

Gen. VIII. 21. 22. Appears to intimate that there was then, for the time, a suspension not only of the diurnal, but of the annual Motion of the earth, and consequently of Summer & Winter, as well as of Day and Night. So that Fossils destitute of Gravity should not be flung according to the diurnal Motion of the earth. — — Dr Woodward here seems to admit so much gravity as to Affect the Vegetables and Animals but not the Fossils, how this can be I know not. — ~~Why~~ How could the Gravity cease or be diminished at all, since the Cause thereof, the Light and Air remained? By a miraculous Power, which preserved the Ark also.

The great Principles of Natural Actions or Motions.

Effects of a Candle under a close Vessel.

Upon the removal of the divergency ~~Refrangibility~~ of colours from refracting Telescopes. see p. 215.

Refraction & refrangibility of light, in passing thro' different mediums.

The great Principle of Nature is this, In all elastic Fluids, the denser parts always press towards the rarer, that the equilibrum of both may be restored. 2.dly The Pressure, Strength, or actions of fluids in motion, upon bodies in fluids, &c. are as the Activity and quantity of Matter or Density of the fluid: thus, by putting a small Candle under a large Receiver of an Air-pump, the Air within is expanded & put into an active motion by the Candle, and so will depress the mercury in the gage, much lower than the outward surface in the vessel in which the gage is placed: but in a short time, the air passes thro' the Candle, is generated into light, (a much rarer fluid) and flies out of the receiver; as soon as this rarifaction does not counterballance the activity, the mercury will rise higer in the gage than in the vessel. Water Rising in the ratio of 30 to 1 to that of mercury, will be much more sensible in this experiment. W.J.

N.° XCVIII. (of the Phil. Trans. Vol. 50. part. 2. & for 1758.) An account of some Experiments concerning the different Refrangibility of Light. By Mr John Dollond. With a Letter from James Short, M. A. F. R. S. Acad. Reg. Suec. Soc.

Dear Sir,

Read June 8, 1758. I have received the inclosed paper from Mr Dollard, which he desires may be laid before the Royal Society. It contains the theory of correcting the errors arising from the different refrangibility of the rays of light in the object-glasses of refracting telescopes; ~~now according~~ and I have found, upon examination, that telescopes made according to this theory are intirely free from colours, and are as distinct as reflecting telescopes. I am,

Dear Sir

Your most obedient humble Servant

Ja. Short.

Surrey-street,
8th June, 1758.

IT is well known, that a ray of light, refracted by passing thro' mediums of different densities, is at the same time proportionally divided or spread into a number of parts, commonly called homogeneal rays, each of a different colour; and that these, after refraction, proceed diverging: a proof, that they are differently refracted, and that light consists of parts that differ in degrees of refrangibility.

Every ray of light passing from a rarer into a denser medium, is refracted towards the perpendicular; but from a denser to a rarer one, from the perpendicular; and the sines of the angles of incidence

Equal refractions of light thro' different mediums, may & does produce different divergencies.

~~Experiment~~

Experiment of equal refractions, but a great divergency of colours.

and refraction are in a given ratio. But light consisting of parts, which are differently refrangible, each part of an original or compound ray has a ratio peculiar to itself; and therefore the more a heterogene ray is refracted, the more will the colours diverge, since the ratios of the sines of the homogene rays are constant; and equal refractions produce equal divergencies.

That this is the case when light is refracted by one given medium only, as suppose any particular sort of glass, is out of all dispute, being indeed selfevident; but the divergency of the colours will be the same under equal refractions, whatsoever mediums the light may be refracted by, tho' generally supposed, does not appear quite so clearly.

However, as no medium is known, which will refract light without diverging the colours, and as difference of refrangibility seems thence to be a property inherent in light itself, Opticians have, upon that consideration, concluded, that equal refractions must produce equal divergencies in every sort of medium: whence it should also follow, that equal and contrary refractions must not only destroy each other, but that the divergency of the colours from one refraction would likewise be corrected by the other; and there could be no possibility of producing any such thing as refraction, which would not be affected by the different refrangibility of light; or, in other words, that however a ray of light may be refracted backwards and forwards by different mediums, as water, glass, &c. provided it was so done, that the emergent ray should be parallel to the incident one, it would ever after be white, and, conversely, if it should come out inclined to the incident, it would diverge, and ever after be coloured. From which it was natural to infer, that all spherical object-glasses of telescopes must be equally affected by the different refrangibility of light, in proportion to their apertures, whatever materials they may be formed of.

But it seems worthy of consideration, that notwithstanding this notion has generally been adopted as an incontestable truth, yet it does not seem to have been hitherto so confirmed by evident experiment, as the nature of so important a matter justly ~~[illegible]~~ demands; and this it was that determined me to attempt putting the thing to issue by the following experiment.

I cemented together two plates of parallel glasses at their edges, so as to form a prismatic or wedge-like vessel, when stopped at the ends or bases; and its edge being turned downwards, I placed therein a glass prism with one of its edges upwards, and filled up the vacancy with clear water: thus the refraction of the prism was contrived to be contrary to that of the water, so that a ray of light transmitted thro' both these refracting mediums would be refracted by the difference only between the two refractions. Wherefore, as I found the water to refract more or less than the ~~prism~~ glass prism, I diminished or increased the angle between the glass plates, till I found the two contrary refractions to be equal: which I discovered by viewing an object thro' this double prism; which when it appeared neither raised nor depressed, I was satisfied, that the refractions were equal, and that the emergent rays were parallel to the incident.

Now,

Now, according to the prevailing opinion, the object should have appeared thro' this double prism quite of its natural colour; for if the difference of refrangibility had been equal in the two equal refractions, they would have rectified each other: but the experiment fully proved the fallacy of this received opinion, by shewing the divergency of light by the prism to be almost double of that by the water; for the object, tho' not at all refracted, was yet as much infected with prismatic colours, as if it had been seen thro' a glass wedge only, whose refracting angle was near 30 degrees.

N. B. This experiment will ~~really~~ be readily perceived to be the same as that which Sir Isaac Newton mentions; (Book I. Part ii. Prop. 3. Experiment 8. of his optics) but how it comes to differ so very remarkably in the result, I shall not take upon me to account for; but will only add, that I used all possible precaution and care in the process, and that I kept the apparatus by me to evince the truth of what I write, whenever I may be properly required so to do.

I plainly saw then, that if the refracting angle of the ~~vessel~~ water-vessel could have admitted of a sufficient increase, the divergency of the coloured rays would have been greatly diminished; or intirely rectified; and there would have been a very great refraction without colour, as now I had a very great discolouring without refraction: but the inconveniency of so large an angle, as that of the vessel must have been, to bring the light to an equal divergency with that of the glass prism, whose angle was about 60 degrees, made it necessary to try some experiments of the same kind, by smaller angles.

I ground a wedge of common plate glass to an angle somewhat less than 9 degrees, which refracted the mean rays about 5 degrees. I then made a wedge-like vessel, as in the former experiment, and filling it with water, managed it so, that it refracted equally with the glass wedge; or, in other words, the difference of their refractions was nothing, and objects viewed thro' them appeared neither raised nor depressed. This was done with an intent to observe the same thing over again in these small angles, which I had seen in the prism: and it appeared indeed the same in proportion, or as near as I could judge; for notwithstanding the refractions ~~[illegible]~~ were here also equal, yet the divergency of the colours by the glass was vastly greater than that by the water; for objects seen by these two refractions were very much discoloured. Now this was a demonstration, that the divergency of the light, by the different refrangibility, was far from being equal in these two refractions. I also saw, from the position of the colours, that the excess of the divergency was in the glass; so that I increased the angle of the water wedge, by different trials, till the divergency of the light by the water was equal to that by the glass; that is, till the object, tho' considerably refracted, by the excess of the refraction of the water, appeared nevertheless quite free from any colours proceeding from the different refrangibility of light; and, as near as I could then measure, the refraction by the water was about $\frac{5}{4}$ of that by the Glass. Indeed I was not very exact in taking the measures, because my business was not at that time about the proportions, so much as to shew, that the divergency of the colours, by different substances, was by no means in proportion

to

What sorts of glass will produce different divergency with equal refractions, & vicè versâ

to the refractions; and that there was a possibility of refraction without any divergency of the light at all.

Having, about the beginning of the year 1757, tried these experiments, I soon after set about grinding telescopic object-glasses upon the new principles of refractions which I had gathered from them; which object-glasses were compounded of two spherical glasses with water between them. These glasses I had the satisfaction to find, as I had expected, free from the errors arising from the different refrangibility of light: for the refractions, by which the rays were brought to a focus, were every-where the differences between two contrary refractions, in the same manner, and in the same proportions, as in the experiment with the wedges.

However, the images formed at the focii of the object-glasses were still very far from being so distinct as might have been expected from the removal of so great a disturbance; and yet it was not very difficult to guess at the reason, when I considered, that the radii of the spherical surfaces of those glasses were required to be so short, in order to make the refractions in the required proportions, that they must produce aberrations, or errors, in the image, as great, or greater, than those from the different refrangibility of light. And therefore, seeing no method of getting over that difficulty, I gave up all hopes of succeeding in that way.

And yet, as these experiments clearly proved, that different substances diverged the light very differently, in proportion to the refraction; I began to suspect, that such variety might possibly be found in different sorts of glass, especially as experience had already shewn, that some made much better object-glasses, in the usual way, than others: and as no satisfactory cause had as yet been assigned for such different, there was great reason to presume, that it might be owing to the different divergency of the light by their refractions.

Wherefore, the next business to be undertaken, was to grind wedges of different kinds of glass, and apply them together, so that the refractions might be made in contrary directions, in order to discover, as in the foregoing experiments, whether the refraction and divergency of the colours would vanish together. But a considerable time elapsed before I could set about that work; for tho' I was determined to try it at my leisure, for satisfying my own curiosity, yet I did not expect to meet with a difference sufficient to give room for any great improvement of telescopes; so that it was not till the latter end of the year that I undertook it, when my first trials convinced me, that this business really deserved my utmost attention and application.

I discovered a difference, far beyond my hopes, in the refractive qualities of different kinds of glass, with respect to their divergency of colours. The yellow or straw-coloured foreign sort, commonly called Venice glass, and the English crown glass, are very near alike in that respect, tho' in general the crown glass seems to diverge the light rather the least of the two. The common plate glass made in England

A Theorem of the aberration of the Rays of Light refracted through a Lens, on Account of its Spherical Figure, by the Revd. Mr. Nevil Maskelyne, F. R. S. Philos. Trans. 1761. Vol. 52. No. 4. p. 17.

Let the Form of the Lens assumed, in the Investigation of the Theorem, be a Meniscus, the Radius of whose convex Surface is greater than that of its concave Surface; and the Center of whose two Surfaces lies on the same Side of the Lens, as the radiant Point, from which the Rays diverge, that fall thereon. The Ray falling on the extreme Part of the Lens will, after Refraction, diverge from a Point before the Lens, nearer thereto than the geometrical ~~[illegible]~~ Focus of Rays diverging from the same Radiant Point, and passing indefinitely near the Vertex.

Let Q express the Distance of the radiant Point, before the Lens, from its Vertex; R the Radius of the Concavity of the Surface, on which the Rays ~~fall~~ first fall; and r the Radius of Convexity of the second Surface; F the principal Focus, or the Focus of parallel Rays, which will be on the same Side of the Lens, as the incident Rays, because R, the Radius of the concave Surface, is supposed less than r, the Radius of the convex Surface. Let the Ratio of m to n be the same with that of the Sine of Incidence to the Sine of Refraction of Rays passing out of Air into Glass, and let Y express the Semidiameter of the Aperture of the Lens; the Angular Aberration of the Ray falling on the Extremity of the Lens, and another Ray or Line, suppose to be drawn from the same Extremity of the Lens, to the geometrical Focus of Rays diverging from the same Radiant Point, and passing indefinitely near the Vertex of the Lens, expressed in Measures of the Arc of a Circle to the Radius of Unity, will be

$$\frac{\overline{m^3-2m^2n+2n^3}\times Y^3}{\overline{m-n}|^2\times 2m\times F^3}+\frac{\overline{mn+4n^2-2m^2}\times Y^3}{\overline{m-n}\times 2m\times F^2r}+\frac{\overline{m+2n}\times Y^3}{m\times QFr}$$

$$-\frac{\overline{4n^2+3mn-3m^2}\times Y^3}{\overline{m-n}\times 2m\times QF^2}-\frac{\overline{2m+2n}\times Y^3}{m\times QFr}+\frac{\overline{3m+2n}\times Y^3}{2m\times Q^2F}.$$

where R, the Radius of the first Surface, is exterminated; and r, the Radius of the second Surface, is retained.

Or, exterminating r, the Radius of the second Surface, and retaining R, the Radius of the ~~second~~ first Surface, the angular Aberration is likewise expressed by

$$\frac{m^2\times Y^3}{2\times\overline{m-n}|^2\times F^3}-\frac{\overline{2m+n}\times Y^3}{2\times\overline{m-n}\times F^2R}+\frac{\overline{m+2n}\times Y^3}{2m\times FR^2}+$$

$$\frac{\overline{3m+n}\times Y^3}{2\times\overline{m-n}\times QF^2}-\frac{\overline{2m+2n}\times Y^3}{m\times QFR}+\frac{\overline{3m+2n}\times Y^3}{2m\times Q^2F}.$$

It may be proper to remark, that, as in these Theorems, the principal Focus is supposed to lie before the Glass, as well as the radiant Point, to adapt the Theorem to other ~~[illegible]~~ Uses, if the Lens be of such a Form, as that its principal Focus lies behind the Glass, F must be taken negative: Likewise if the Rays fall ~~[illegible]~~ converging on the Lens, or the Point, to which they converge, lies behind the Glass, Q must be taken negative: Lastly, if the first Surface be convex, R must be taken negative, and if the second Surface be concave, r must be taken negative; and if, after all these Circumstances are all allowed for, the Value of the Theorem comes out positive, the Aberration is of such a Nature, as to make the Focus of the extreme Rays fall nearer the Lens before it, than the geometrical Focus, or farther from the Lens behind it: But if the Value of the Theorem comes out negative, the Aberration is of such a kind as to make the Focus of the extreme Rays fall farther from the Lens before it, than the geometrical Focus.

(Continued on p: 79.)

diverges more; and the white crystal or flint English glass, as it
is called, most of all.

It was not now my business to examine into the particular qualities of every kind of glass, that I could come at, much less to amuse myself with conjectures about the cause, but to fix upon such two sorts as their difference was the greatest; which I soon found to be the crown, and the white flint or crystal. I therefore ground a wedge of white flint of about 25 degrees, and another of crown of about 29 degrees, which refracted nearly alike; but their divergency of the colours was very different. I then ground several others of crown to different angles, till I got one, which was equal, with respect to the divergency of the light, to that in the white flint: for when they were put together, so as to refract in contrary directions, the refracted light was intirely free from colour. Then measuring the refractions of each wedge, I found that of the white glass to be to that of the crown nearly as 2 to 3; and this proportion would hold very near in all small angles. Wherefore any two wedges made in this proportion, and applied together, so as to refract in contrary direction, would refract the light without any difference of refrangibility.

To make therefore two spherical glasses, that shall refract the light in contrary directions, it is easy to understand, that one must be concave, and the other convex; and as the rays are to converge to a real focus, the excess of refraction must evidently be in the convex; and as the convex is to refract most, it appears from the experiment, that it must be made with crown glass, and the concave with white flint glass.

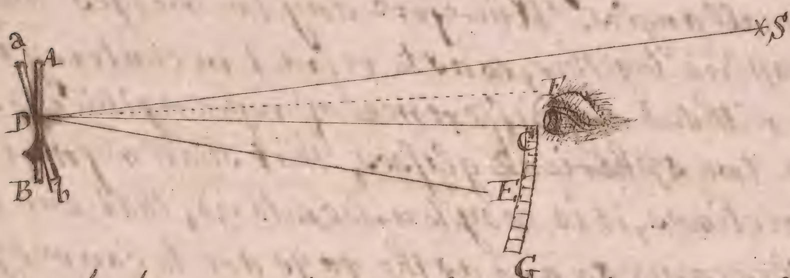
And further, as the refractions of spherical glasses are in an inverse ratio of their focal distances; it follows, that the focal distances of the two glasses should be inversely as the ratio's of the refractions of the wedges: for being thus proportioned, every ray of light, that passes thro' this combined glass, at whatever distance it may pass thro' its axe, will constantly be refracted, by the difference between ~~the~~ two contrary refractions, in the proportion required; and therefore the different refrangibility of the light will be intirely removed.

Having thus got rid of the principal cause of the imperfection of refracting telescopes, there seemed to be nothing more to do, but to go to work upon this principle: but I had not made many attempts, before I found, that the removal of one impediment had introduced another equally detrimental (the same as I had before found in two glasses with water between them): for the two glasses, that were to be combined together, were the segments of very deep spheres; and therefore the aberrations from the spherical surfaces became very considerable, and greatly disturbed the distinctness of the image. Tho' this appeared at first a very great difficulty, yet I was not long

without

A Continuation of p. 77.

With respect to the Application of this Theorem to Mr Dolland's combined Object-glasses, it is evident, that if the Aberrations of the convex and concave Lenses added together (paying due Regard to the Signs of the Theorem), are made equal to nothing, the two Lenses will perfectly correct one another: But as there are two unknown Quantities unlimited in the Equation, namely, the Radius of one Surface of each Glass (for F and Q are given, as well as m and n), there is room for an arbitrary Assumption of one of them, at the Discretion of of the Theorist, or Artist; which being done, there will remain a quadratic Equation, whence there will result two Values of the Radius, which remains unknown, either of which will produce an Aberration equal to that of the other Lens.



A demonstration of the Speculum in Hadley's Quadrant. Or that the Angle formed by the Speculum at the Center, and a perpendicular to the Horizon is equal to the Altitude of the object taken by the quadrant. By myself.

Let AB (in the fig. above) be a plano-speculum, C the Eye of the observer situated in the horizontal line DC & ⊥ to AB; then if S be a Star, the ∠SDC = Altitude, but since ∠CDS = CDE, by Optics, the Ray SD proceeding in the direction DE, and therefore invisible at C: Wherefore, to have it visible at C, let DF bisect SDC; then ∠SDF, called the angle of incidence = FDC, the ∠ of Refraction, consequently DF is ⊥ to the Speculum in the position ab.

Now if the common ∠ADF be taken from the two Right angles ADC, aDF, there will remain FDC = aDA, i.e. half the Altitude of the the Star S is equal to the Angle made by the Speculum and a perpendicular to the Horizon. Wherefore, to measure Altitudes with a Speculum, in the center of a quadrant, an Octant will serve the purpose, which must not be divided into 45 but 90 equal parts for degrees.

A computation of the rise of water against obstacles placed in a running stream, and the fall of the water, on the other side, made thereby.

On Caleb Smith's Quadrant.

I have an Old quadrant with the telescope fixed parallel to the limb of Hadley's quadrant, and a solid prismatic glass at the center invented by Caleb Smith. Something Similar to which see Philos. Trans. Vol. VI. part I. p. 141. of Martyn's Abridgment. Also Vol. VIII. p. 129. Stone, in his Appendix to Bion, p. 268. Says Smith published a plate of his quad.t

without hopes of a remedy: for considering, the surfaces of spherical glasses admit of great variations, tho' the focal distance be limited, and that by these variations their aberrations may be made more or less, almost at pleasure; I plainly saw the possibility of making the aberrations of any two glasses equal; and as in this case the refractions of the two glasses were contrary to each other, their aberrations, being equal, would intirely vanish.

And thus, at last, I obtained a perfect theory for making object-glasses, to the apertures of which I could scarce conceive any limits: for if the practice could come up to the theory, they must certainly admit of very extensive ones, and of course bear very great magnifying powers.

But the difficulties attending the practice are very considerable. In the first place, the focal distances, as well as the particular surfaces, must be very nicely proportioned to the densities or refracting powers of the glasses; which are very apt to vary in the same sort of glass made at different times. Secondly, the centres of the two glasses must be placed truly on the common axis of the telescope; otherwise the desired effect will be in a great measure destroyed. Add to these, that there are four surfaces to be wrought perfectly spherical; and any person, but moderately practised in optical operations will allow, that there must be the greatest accuracy throughout the whole work.

Notwithstanding so many difficulties, as I have enumerated; I have, after numerous trials, and a resolute perseverance, brought the matter at last to such an issue, that I can construct refracting telescopes, with such apertures and magnifying powers, under limited lengths, as, in the opinion of the best and undeniable judges, who have experienced them, far exceed any thing that has been hitherto produced, as representing objects with great distinctness, and in their true colours.

John Dollond.

See p. 215. and Philos. Trans. Vol. 53. for 1763. N.o 31. p. 173.

N.° LXIII. (of the Philos. Trans. Vol. 50. Part 2.d for 1758.)

Concering the Fall of Water under Bridges. By M.r J. Robertson, F.R.S.

Read Jan. 19. 1758. SOME time before the year 1740, the problem about the fall of water, occasioned by the piers of bridges built across a river, was much talked of at London, on account of the fall that it was supposed would be at the new bridge to be built at Westminster. In M.r Hawksmore's and M.r Labeleye's pamphlets, the former published in 1736, and the latter in 1739, the result of M.r Labelye's computations was given: but neither the investigation of the problem, nor any rules, were at that time exhibited to the public.

In the year 1742 was published Gardiner's edition of Vlacq's Tables; in which, among the examples there prefixed to shew some of the uses of those tables drawn up by the late William Jones, Esq; there

81) there are two examples, one shewing how to compute the fall of water at London-bridge: but that excellent mathematician's investigation of the rule, by which those examples were wrought, was not printed altho' he communicated to several of his friends copies thereof. Since that time, it seems as if the problem had in general been forgot, as it has not made its appearance, to my knowledge, in any of the subsequent publications. As it is a problem somewhat curious, tho' not difficult, and its solution not generally known (having seen four different solutions, one of them very imperfect, extracted from the private books of an office in one of the departments of engineering in a neighbouring nation), I thought it might give some entertainment to the curious in these matters, if the whole process were published. In the following investigation, much the same with Mr Jones's, as the demonstrations of the principles therein used appear to be wanting, they are here attempted to be supplied.

PRINCIPLES. I. A heavy body, that in the first second of time has fallen the height of a feet; has acquired such a velocity, that, moving uniformly therewith, will in the next second of time move the length of 2a feet.

II. The spaces run thro' by falling bodies are proportional to one another as the squares of their last or acquired velocities.

These two principles are demonstrated by the writers on mechanics.

III. Water forced out of a larger channel thro' one or more smaller passages, will have the streams thro' those passages contracted in the ratio of 25 to 21.

This is shewn in the 36th prop. of the 2d book of Newton's Principia.

IV. In any stream of water, the velocity is such, as would be acquired by the fall of a body from a height above the surface of that stream.

This is evident from the Nature of motion.

V. The velocity of water thro' different passages of the same height, are reciprocally proportional to their breadths.

For, at some time, the water must be delivered as fast as it comes; otherwise the bounds would be overflowed.

At that time, the same quantity, which in any time flows thro' a section in the open channel, is delivered in equal time thro' the narrower passages; or the momentum in the narrow passages must be equal to the momentum in the open chanel; or the rectangle under the section of narrow passages, by their mean velocity, must be equal to the rectangle under the section of the open chanel by its mean velocity. — Therefore the velocity in the open chanel is to the velocity in the narrower passages, as the section of those passages is to the section of the open chanel.

But the heights in both sections being equal, the sections

sections are directly as the breadths;

Consequently the velocities are reciprocally as the breadths.

VI. In a running stream, the water above any obstacles put therein will rise to such a height, that by its fall the stream may be discharged as fast as it comes.

For the same body of water, which flowed in the open chanel, must pass thro' the passages made by the obstacles:

And the narrower the passages, the swifter will be the velocity of water:

But the swifter the velocity of the water, the greater is the height, from whence it has descended:

Consequently the obstacles, which contract the chanel, cause the water to rise against them.

But the rise will cease, when the water can run off as fast as it comes:

And this must happen, when, by the fall between the obstacles, the water will acquire a velocity in a reciprocal proportion to that in the open chanel as the breadth of the open chanel is to the breadth of the narrow passages.

VII. The quantity of the fall caused by an obstacle in a running stream is measured by the difference between the heights fallen from to acquire the velocity in the narrow passages and open chanel.

For just above the fall, the velocity of the stream is such, as would be acquired by a body falling from a height higher than the surface of the water:

And at the fall, the velocity of the stream is such, as would be acquired by the fall of a body from a height more elevated than the top of the falling stream; and consequently the real fall is less than this height.

Now as the stream comes to the fall with a velocity belonging to a fall above its surface;

Consequently the height belonging to the velocity at the fall must be diminished by the height belonging to the velocity with which the stream arrives at the fall.

PROBLEM. In a chanel of running water, whose breadth is contracted by one or more obstacles; the breadth of the chanel, the mean velocity of the whole stream, and the breadth of the water way between the obstacles being given; To find the quantity of the fall occasioned by those obstacles.

Let b = breadth of the chanel in feet.

v = mean velocity of the water in feet per sec.

c = breadth of the water-way between the obstacles.

Now $25 : 21 :: c : \frac{21}{25}c$ the water-way contracted ... Princip. III

And $\frac{21}{25}c : b :: v : \frac{25b}{21c}v$ the velocity per sec. in the water-way between the obstacles. ------ -- Princip. V.

Also $\overline{2a}^2 : vv :: a : \frac{vv}{4a}$ the height fallen to acquire the vel. v. ---------------- I. & II.

And $\overline{2a}^2 : \overline{\frac{25b}{21c}}\Big|^2 \times vv :: a : \overline{\frac{25b}{21c}}\Big|^2 \times \frac{vv}{4a}$ the height

fallen

fallen to acquire the velocity $\frac{25b}{21c}v$. - - - - - - - I. & II.

Then $\overline{\frac{25b}{21c}}\Big|^2 \times \frac{vv}{4a} - \frac{vv}{4a}$ is the measure of the fall required. — VII.

or $\overline{\frac{25b}{21c}\Big|^2 - 1} \times \frac{vv}{4a}$ is a rule, by which the fall may be readily computed.

Here $\underline{a} = 16,0899$ feet and $4\underline{a} = 64,3596$.

EXAMPLE I. <u>For London-bridge.</u>

By the observations made by Mr. Labeleye in 1746, The breadth of the Thames at London-bridge is 926 feet; The sum of the water-ways at the time of the greatest fall is 236 feet;

The mean velocity of the stream taken at its surface just above bridge is $3\frac{1}{6}$ feet <u>per</u> second.

Under almost all the Arches there are great numbers of drip-shot piles, or piles driven into the bed of the water-way, to prevent it from being washed away by the fall. These drip-shot piles considerably contract the water-ways, at least $\frac{1}{6}$ of their measured breadth, or about $39\frac{1}{3}$ feet in the whole. So that the water-way will be reduced to $196\frac{2}{3}$ feet.

Now $b = 926$; $c = 196\frac{2}{3}$; $v = 3\frac{1}{6}$; $4a = 64,3596$.

Then $\frac{25b}{21c} = \frac{23150}{4130} = 5,60532$.

And $\overline{5,60532}\big|^2 = 31,4196$; and $31,4196 - 1 = 30,4196 = \overline{\frac{25b}{21c}}\Big|^2 - 1$.

Also $vv = \overline{\frac{19}{6}}\Big|^2 = \frac{361}{36}$; And $\frac{vv}{4a} = \frac{361}{36 \times 64,3596} = 0,15581$.

Then $30,4196 \times 0,15581 = 4,739$ feet, the fall sought after.

By the most exact observations made about the year 1736, the measure of the fall was 4 feet 9 inches.

EXAMPLE II. For Westminster-Bridge.

Altho' the breadth of the river at Westminster Bridge is 1220 feet; yet, at the time of the greatest fall, there is water thro' ~~all the~~ only the thirteen large arches, which amount to 820 feet: to which adding the breadth of the twelve intermediate piers, equal to 174 feet, gives 994 for the breadth of the river at that time: and the velocity of the water just above the bridge (from many experiments) is not greater than $2\frac{1}{4}$ feet <u>per</u> second.

Here $b = 994$; $c = 820$; $v = 2\frac{1}{4}$; $4a = 64,3596$,

Now $\frac{25b}{21c} = \frac{24850}{17220} = 1,443$.

And $\overline{1,443}\big|^2 = 2,082$; And $2,082 - 1 = 1,082 = \overline{\frac{25b}{21c}}\Big|^2 - 1$

Also $vv = \left.\frac{9}{4}\right|^2 = \frac{81}{16}$; And $\frac{vv}{48} = \frac{81}{16 \times 64,3596} = 0,0786$.

Then $1,082 \times 0,0786 = 0,084$ feet, the fall sought.

Which is about 1 inch; and is about half an inch more than the greatest fall observed by Mr Labeleye.

A general method for Isoperimetrical Problems.

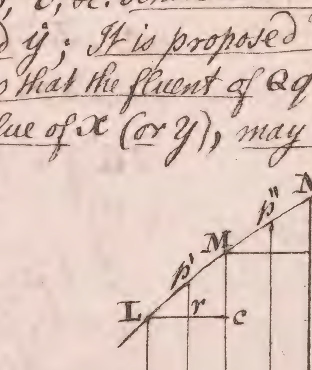
The paper mentioned is at p. 102.

LXXXV. (of the Philo. Trans. Vol. 50 Part 2. & for 1758) A further Attempt to facilitate the Resolution of Isoperimetrical Problems. By Mr Thomas Simpson, F. R. S.

Read April 13. 1758.

ABOUT three years ago I had the honour to lay before the Royal Society the investigation of a general rule for the resolution of isoperimetrical problems of that kind, wherein one, only, of the two indeterminate quantities enters along with the fluxion, into the equations expressing the conditions of the problem. Under which kind are included the determination of the greatest figures under given bounds, lines of the swiftest descent, solids of the least resistance, with innumerable other cases. But altho' cases of this sort do, indeed, most frequently occur, and have therefore been chiefly attended to by mathematicians, others may nevertheless be proposed, such as actually arise in inquiries into nature, wherein both the flowing quantities, together with their fluxions, are jointly concerned. The investigation of a rule for the resolution of these, is what I shall in this paper attempt, by means of the following

GENERAL PROPOSITION. Let Q, R, S, T, &c. represent any variable quantities, expressed in terms of x and y (with given coefficients), and let q, r, s, t, &c. denote as many other quantities, expressed in terms of $\dot{x}$ and $\dot{y}$; It is proposed to find an equation for the relation of x and y, so that the fluent of $Qq + Rr + Ss + Tt$, &c. corresponding to a given value of x (or y), may be a maximum or minimum.



This is also made Fig. 8.

Let AE, AF, and AG, denote any three values of the quantity x, having indefinitely small equi-differences EF FG; and let EL, FM, and GN, (perpendicular to AG) be the respective values of y, corresponding thereto, and, supposing EF $(= FG = \dot{x})$ to be denote by e, let cM and dN (the successive values of $\dot{y}$) be represented by u and w. Moreover, supposing $P'p'$ and $P''p''$ to be ordinates at the middle points P' P'', between E, F and F, G, let the former $(P'p')$ be denoted by α, and the latter $(P''p'')$ by β; putting $AP' = a$ and $AP'' = b$. Then, if a and α (the mean values of x and y, between the ordinates EL and FM) be suppose to be substituted for x and y, in the given quantity $Qq + Rr + Ss + Tt$, &c. and if, instead of $\dot{x}$ and $\dot{y}$, their equals e and u be also substituted, and the said (given) quantity, after such substitution, be denoted by

by $\acute{Q}q+\acute{R}r+\acute{S}s+\acute{T}t$, &c. it is then evident, that this quantity $Q'q+R'r+S's+T't$, &c. will express so much of the whole required fluent, as is comprehended between the ordinates EL and EM, or as answers to an increase of EF in the value of x. And thus, if b and β be conceived to be wrote for x and y, e for $\dot{x}$, and w for $\dot{y}$, and the quantity resulting be denoted by $Q''q''+R''r''+S''s''+T''t''$, &c. this quantity will, in like manner, express the part of the required fluent corresponding to the interval FG. Whence that part answering to the interval EG will consequently be equal to $Q'q+R'r$ &c. $+\,Q''q''+R''r''$ &c. But it is manifest, that the whole required fluent cannot be a maximum or minimum, unless this part, supposing the bounding ordinates EL, GN to remain the same, is also a maximum or minimum. Hence, in order to determine the fluxion of this expression ($Q'q+R'r'$ &c. $Q''q''+R''r''$ &c.) which must, of consequence, be equal to nothing, let the fluxion of Q' and q' (taking a and u as variable) be denoted by $\bar{Q}\dot{\alpha}$ and $\bar{q}\dot{u}$; also let $\bar{R}\dot{\alpha}$ and $\bar{r}\dot{u}$ denote the respective fluxions of R' and r'; and let, in like manner, the fluxions of Q'', q'', R'', r'', &c. be represented by $\bar{\bar{Q}}\dot{\beta}$, $\bar{\bar{q}}\dot{w}$, $\bar{\bar{R}}\dot{\beta}$, $\bar{\bar{r}}\dot{w}$, &c. respectively. Then, by the common rule for find the fluxion of a rectangle, the fluxion of our whole expression ($Q'q'+R'r'$ &c. $+\,Q''q''+R''r''$ &c. will be given equal to $Q'\bar{q}\dot{u}+q'\bar{Q}\dot{\alpha}+R'\bar{r}\dot{u}+r'\bar{R}\dot{\alpha}$ &c. $+\,Q''\bar{\bar{q}}\dot{w}+q''\bar{\bar{Q}}\dot{\beta}+R''\bar{\bar{r}}\dot{w}$ $+\,r''\bar{\bar{R}}\dot{\beta}$ &c. $=0$.

But $u+w$ being $=GN-EL$, and $\beta-a=\frac{GN-EL}{2}$ (a constant quantity), we therefore have $\dot{w}=-\dot{u}$, and $\dot{\beta}=\dot{\alpha}$: also u being ($=2rp'$) $2\alpha-2EL$, thence will $\dot{u}=2\dot{\alpha}$: which values being substituted above, our equation, after the whole is divided by $\dot{\alpha}$, will become

$$2Q'\bar{q}+q'\bar{Q}+2R'\bar{r}+r'\bar{R}, \&c. -2Q''\bar{\bar{q}}+q''\bar{\bar{Q}}-2R''\bar{\bar{r}}+r''\bar{\bar{R}}, \&c. =0; \text{ or } Q''\bar{\bar{q}}-Q'\bar{q}+R''\bar{\bar{r}}-R'\bar{r} \;\&c. = \frac{q'\bar{Q}+q'\bar{\bar{Q}}+r'\bar{R}+r''\bar{\bar{R}}}{2}, \&c.$$

But $Q''\bar{\bar{q}}-Q'\bar{q}$, the excess of $Q''\bar{\bar{q}}$ above $Q'\bar{q}$, is the increment or fluxion (answering to the increment, or fluxion, $\dot{x}$) arising by substituting b for a, β for α, and w for u. Moreover, with regard to the quantities on the other side of the equation, it is plain, seeing the difference of $q'\bar{Q}$ and $\bar{\bar{q}}\,\bar{\bar{Q}}$ is indefinitely little in comparison of their sum, that $q'\bar{Q}$ may be substituted in the room of $\frac{q'\bar{Q}+q''\bar{\bar{Q}}}{2}$, &c. which being done, our equation will stand thus:

Flux. $Q'\bar{q}+R'\bar{r}$ &c. $=q'\bar{Q}+r'\bar{R}$ &c.

But $q'\bar{Q}+r'\bar{R}$ &c. represents (by the preceding notation) the fluxion $q'\dot{Q}'+r'\dot{R}'$ &c. (or of $Qq+Rr$ &c.) arising by substituting α for y, making α alone variable, and casting off $\dot{\alpha}$. If, therefore, that fluxion be denoted by $\dot{v}$, we shall have flux.

$\acute{Q}\bar{q} + \acute{R}\bar{r}$ &c. $= \dot{v}$, and consequently $\acute{Q}\bar{q} + \acute{R}\bar{r}$ &c. $= v$. But $\acute{Q}\bar{q} + \acute{R}\bar{r}$ &c. (by the same notation) appears to be the fluxion of $\acute{Q}q' + \acute{R}r'$ &c. (or of $Qq + Rr$ &c.) arising by substituting $\underline{u}$ for $\dot{y}$, making $\underline{u}$ alone variable, and casting of $\dot{u}$. Whence the following

GENERAL RULE. Take the fluxion of the given expression (whose fluent is required to be a maximum or minimum) making $\dot{y}$ alone variable; and having divided by $\dot{y}$, let the quotient be denoted by v: Then take, again, the fluxion of the same expression, making y alone variable, which divide by $\dot{y}$; and then this last quotient will be $= \dot{v}$.

When y is not found in the quantity given, v will then be $= 0$; and, consequently, the expression for $\dot{v}$, equal to nothing also. But if y be absent, then will $\dot{v} = 0$, and consequently the value of $v =$ to a constant quantity. It is also easy to comprehend, that, instead of $\dot{y}$ and y, $\dot{x}$ and x may be made successively variable. Moreover, should the case to be resolved be confined to other restrictions, besides that of the maximum and minimum, such as, having a certain number of other fluents, at the same time, equal to given quantities, still the same method of solution may be applied, and that with equal advantage, if from the particular expressions exhibiting all the several conditions, one general expression composed of them all, with unknown (but determinate) coefficients, be made use of.

In order to render this matter quite clear, let A, B, C, D, &c. be supposed to represent any quantities expressed in terms of x, y, and their fluxions, and let it be required to determine the relation of x and y, so that the fluent of $A\dot{x}$ shall be a maximum, or minimum, when the cotemporary fluents of $B\dot{x}$, $C\dot{x}$, $D\dot{x}$, &c. are, all of them, equal to given quantities.

It is evident, in the first place, that the fluent of $A\dot{x} + bB\dot{x} + cC\dot{x} + dD\dot{x}$, &c. ($b$, c, d, &c. being any constant quantities whatever) must be a maximum, or minimum, in the proposed circumstances: and, if the relation of x and y be determined (by the rule), so as to answer this single condition (under all possible values of b, c, d, &c.) it will also appear evident, that such relation will likewise answer and include all the other conditions propounded. For, there being in the general expression, thus derived, as many unknown quantities b, c, d, &c. (to be determined) as there are equation, by making the fluents of $B\dot{x}$, $C\dot{x}$, $D\dot{x}$, &c. equal to the values given; those quantities may be so assigned, or conceived to be such, as to answer all the conditions of the said equations, And then, to see clearly that the fluent of the first expression, $A\dot{x}$, cannot be greater than arises from hence (other things remaining the same) let there be suppose some other different relation of x and y, whereby the conditions of all the other fluents of $B\dot{x}$, $C\dot{x}$, $D\dot{x}$, &c. can be fulfilled; and let, if possible, this new relation give a greater fluent of $A\dot{x}$ than

than the relation above assigned. Then, because the fluents $\underline{b}B\dot{\underline{x}}$, $\underline{c}C\dot{\underline{x}}$, $\underline{d}D\dot{\underline{x}}$, &c. are given, and the same in both cases, it follows, according to this supposition, that this new relation must give a greater fluent of $A\dot{\underline{x}}+\underline{b}B\dot{\underline{x}}+\underline{c}C\dot{\underline{x}}+\underline{d}D\dot{\underline{x}}$, &c. (under all possible values of $\underline{b}$, $\underline{c}$, $\underline{d}$, &c.) than the former relation gives: which is impossible; because (whatever values are assigned to $\underline{b}$, $\underline{c}$, $\underline{d}$, &c.) that fluent will, it is demonstrated, be the greatest possible, when the relation of $\underline{x}$ and $\underline{y}$ is that above determined, by the General Rule.

To exemplify, now, by a particular case, the method of operation above pointed out, let there be proposed the fluxionary quantity $\frac{x^n y^m \dot{y}^p}{\dot{x}^{p-1}}$; wherein the relation of $\underline{x}$ and $\underline{y}$ is so required, that the fluent, corresponding to given values of $\underline{x}$ and $\underline{y}$, shall be a maximum, or minimum. Here, by taking the fluxion, making $\dot{y}$ alone variable (according to the rule) and dividing by $\dot{y}$, we shall have $\frac{px^n y^m \dot{y}^{p-1}}{\dot{x}^{p-1}} = v$. And, by taking the fluxion a second time, making y alone variable, and dividing by $\dot{y}$, will be had $\frac{mx^n y^{m-1} \dot{y}^p}{\dot{x}^{p-1}} = \dot{v}$. Now from these equations to exterminate v, let the latter be divided by the former; so shall $\frac{m\dot{y}}{py} = \frac{\dot{v}}{v}$; & therefore $ay^{\frac{m}{p}} = v$ (a being a constant quantity). From whence $y^{\frac{m}{p}}\dot{y} = \left.\frac{a}{p}\right|^{\frac{1}{p-1}} \times \dot{x}x^{-\frac{n}{p-1}}$; and consequently $\frac{p}{m+p} \times y^{\frac{m+p}{p}} = \left.\frac{a}{p}\right|^{\frac{1}{p-1}} \times \frac{p-1}{p-n-1} \times x^{\frac{p-n-1}{p-1}}$.

Let there be now proposed the two fluxions $x^n y^m \dot{x}$ and $x^p y^q \dot{y}$, the fluent of the former being required to be a maximum, or minimum, and that of the latter, at the same time, equal to a given quantity. Then the latter, with the general coefficient $\underline{b}$ prefixed, being joined to the former, we shall here have $x^n y^m \dot{x} + bx^p y^q \dot{y}$. From whence, by proceeding as before, $bx^p y^q = v$, and $mx^n y^{m-1}\dot{x} + qbx^p y^{q-1}\dot{y} = \dot{v}$. From the former of which equations, by taking the fluxions on both sides, will be had $pbx^{p-1}y^q\dot{x} + qbx^p y^{q-1}\dot{y}$ $(=\dot{v}) = mx^n y^{m-1}\dot{x} + qbx^p y^{q-1}\dot{y}$. Whence $pbx^{p-1}y^q = mx^n y^{m-1}$; and therefore $pby^{q-m+1} = mx^{n-p+1}$. And in the same manner, proper equations, to express the relation of $\underline{x}$ and $\underline{y}$, may be derived, in any other case, and under any number of limitations.

LXXIII. Of the best Form of Geographical Maps. By the Rev.d Patrick Murdock, M.A. F.R.S.

Read Feb. 9. 1758. I. WHEN any portion of the earth's surface is projected on a plane, or transferred to it by whatever method of description, the real dimentions, and very often the figure and position of countries, are much

much altered and misrepresented. In the common projection of the two hemispheres, the meridians and parallels of latitude do indeed intersect at right angles, as on the globe; but the linear distances are every-where diminished, excepting only at the extremity of the projection: at the center they are but half their just quantity, and thence the superficial dimensions but one-fourth part: and in less general maps this inconvenience will always, in some degree, attend the stereographic projection.

The orthographic, by parallel lines, would be still less exact, those lines falling altogether oblique on the extreme parts of the hemisphere. It is useful, however, in describing the circum-polar regions: and the rules of both projections, for their elegance, as well as for their uses in astronomy, ought to be retained, and carefully studied. As to Wright's, or Mercator's, nautical chart, it does not here fall under our consideration: it is perfect in its kind; and will always be reckoned among the chief inventions of the last age. If it has been misunderstood, or misapplied, by geographers, they only are to blame.

II. The particular methods of description proposed or used by geographers are so various, that we might, on that very account, suspect them to be faulty; but in most of their works we actually find these two blemishes, the linear distances visibly false, and the intersections of the ~~circles~~ circles oblique: so that a quadrilateral rectangular space shall often be represented by an oblique-angled rhomboid figure, whose diagonals are very far from equal; and yet, by a strange contradiction, you shall see a fixed scale of distances inserted in such a map.

III. The only maps I remember to have seen, in which the last of the blemishes is removed, and the other lessened, are some of P. Schenk's of Amsterdam, a map of the Russian empire, the Germania Critica of the famous Professor Meyer, and a few more ‡. In these the meridians are straight lines converging to a point; from which, as a center, the parallels of latitude are described: and a rule has been published for the drawing of such maps *. But as that rule appears to be only an easy ~~approximation~~ and convenient approximation, it remains still to be inquired, What is the construction of a particular map, that shall exhibit the superficial and linear measures in their truest proportion? In order to which,

IV. Let ELLP, in fig. 1. be the quadrant of a meridian of a given sphere, whose center is C, and its pole P; EL, El, the latitudes of two places in that meridian, EM their middle latitude. Draw LN, ln, cosines of the latitudes, the sine of the middle latitude MF, and its cotangent MT. Then writing unity for the radius, if in CM we take $Cx = \frac{Nn}{Ll \times MF \times MT}$, and thro' x we draw xR, xr, equal each to half the arc Ll, and perpendicular to CM; the conical surface generated by the line Rr, while the figure revolves on the axis of the sphere, will be equal to the surface of the zone that is to be described in the same time by the arc Ll; as will easily appear by comparing that conical surface with the zone, as measured by Archimedes.

And, lastly, If from the point t, in which rR produced meets the axis, we take the angle CtV in proportion to the longitude of the proposed map, as MF the sine of the middle latitude is to radius, and draw the parallels and meridians as in the figure, the whole space SOQV will be the proposed part of the conical surface expanded into a plane; in which the places may now be inserted according to their known longitudes and latitudes

V. EXAMPLE. Let Ll, the breadth of the zone, be 50°, lying between 10° and 60° north latitude; its longitude 110°, from 20° east of the Canaries to the center of the western hemispher; comprehending the western parts of Europe and Africa, the more known parts of North America, and the ocean that seperates it from the old continent.

And because $Cx = \frac{Nn}{Ll \times MF \times MT}$, add these three logarithms.

‡ Senex drew several of that form.
* See the preface to the small Berlin Atlas.

Log.

Log. 0.8726650 (= 50° to radius 1) - - - - - - $-1,9408476$
Log MF (sine 35°) - - - - - - - - - $-1,7585913$
Log MT (tang. 55° - - - - - - - - - - $0,1547732$
Take the sum - - - - - - - - - - - $-1,8542121$
from log. Nn (=,6923772) - - - - - - - - $-1,8403427$
the remainder - - - - - - - - - - - $-1,9861306$
is the logarithm of Cx. And because 1 : Cx :: MT : xt, to this add
the log. MT - - - - - - - - - - - - $0,1547732$
The sum - - - - - - - - - - - - - $0,1409038$
is the log. of xt = 1.383260; and xR (= xr = ½ Ll) being .4363325, Rt will be 0.9469275, rt = 1,8195925. Whence having fixed upon any convenient size for our map, the center t is easily found. As, allowing an inch to a degree of a great circle, or 50 inches to the line Rr, Rt the semidiameter of the least parallel will be 54, 255 inches, and that of the greatest parallel 104. 255 inches.

Again, making as radius to MF so the longitude 110° to the angle StV, that angle will be 63°. 5′ 3/3. Divide the meridians and parallels, & finish the map as usual.

Note, The log. MT being repeated in this computation with a contrary sign, we may find xt immediately by subtracting the sum of the logarithms of Ll and MF from the log. of Nn.

VI. A map drawn by this rule will have the following properties.

1. The intersections of the meridians and parallels will be rectangular.
2. The distances north and south will be exact; and any meridian will serve as a scale.
3. The parallels thro' Z and y, where the line Rr cuts the arc Ll, or any small distances of places that lie in those parallels, will be of their just quantity. At the extreme latitudes they will exceed, and in mean latitudes, from x towards Z or y, they will fall short of it. But unless the zone is very broad, neither the excess, nor the defect will be any where considerable.
4. The latitudes and the superficies of the map being exact, by the construction, it follows, that the excesses and defects of distance, now mentioned, compensate each other; and are, in general, of the least quantity they can have in the map designed.
5. If a thread is extended on a plane, and fixed to it at its two extremities, and afterwards the plane is formed into a pyramidal or conical surface, it may be easily shewn, that the thread will pass thro' the same points of the surface as before; and that, conversely, the shortest distance between two points in a conical surface is the right line that joins them, when that surface is expanded into a plane. Now, in the present case, the shortest distances on the conical surface will be, if not equal, always nearly equal, to the corresponding distances on the sphere: and therefore, all rectilinear distances on the map, applied to the meridian as a scale, will, nearly at least, shew the true distances of the places represented.
6. In maps, whose breadth exceeds not 10° or 15°, the rectilinear distances may be taken for sufficiently exact. But we have chose our example of a greater breadth than can often be required, on purpose to shew how high the errors can ever arise; and how they may, if it is thought needful, be nearly estimated and corrected.

Write down, in a vacant space at the bottom of the map, a table of the errors of equidistant parallels, as from five degrees to five degrees of the whole latitude; and having taken the mean errors, and diminished them in the ratio of radius to the sine of the mean inclination of the line of distance to the meridian, you shall find the correction required; remembering only to distinguish the distance into its parts that lie within and without the sphere, and taking the difference of the corresponding errors, in defect and in excess.

But it was thought needless to add any examples; as, from what has been said, the intelligent reader will readily see the use of such a table; and chiefly as, whenever exactness is required, it will be more proper, and indeed

indeed more expeditious, to compute the distances of places by the following canon.

Multiply the product of the cosines of the two given latitudes by the square of the sine of half the difference of longitude; and to this product add the square of the sine of half the difference of the latitudes; the square root of the sum shall be the sine of half the arc of a great circle between the two places given. [V. my Trigonometrical M. S. page facing 29. for this Theorem by the same gentleman]

Thus, if we are to find the true distance from one angle of our map to the opposite, that is, from S to Q, the operation will be as follows:

L. sin. 30° = −1,6989700
L. sin. 80° = −1,9933515
2L. sin. 55° = −1,8267290

−1,5190505 = log. of 0,330408

and 2L. sin 25° = −1,2518966 = log. of 0,178606

L. of the sum - - - - 0,509014 is −1,7067297

whose half is - - - −1,8533648

the L. sin. of 45° 31', the double of which is 91° 2' or 5462 geographical miles.

And seeing the lines TS, TQ, reduced to minutes of a degree, are 6225,189 and 3255,189 respectively, and the angle STV is 63° 5 $\frac{3}{5}$, the right line SQ on the map will be 5594, exceeding its just value by 132' or $\frac{1}{42}$ of the whole.

7. The errors on the parallels increasing faster towards the north, and the line SQ having, at last, nearly the same direction, it is not to be wondered that the errors in our example should amount to $\frac{1}{42}$. Greater still would happen, if we measured the distance from O to Q by a straight line joining those points: for that line, on the conic surface, lying every-where at a greater distance from the sphere than the points O and Q, must plainly be a very improper measure of the distance of their correspondent points on the sphere. And therefore, to prevent all errors of that kind, and confine the other errors in this part of our map to narrower bounds, it will be best to terminate it towards the pole by a straight line KI touching the parallel OQ in the middle point K, and on the east and west by the lines, as HI, parallel to the meridian thro' K, and meeting the tangent at the middle point of the parallel SV in H. By this means too we shall gain more space than we lose, while the map takes the usual rectangular form, and the spaces GHV remain for the title, and other inscriptions.

VII. Another, and not the least considerable, property of our maps is, that it may, without sensible error, be used as a sea-chart; the rhumb-lines on it being logarithmic spirals to their common pole t, as is partly represented in the figure: and the arithematical solutions thence derived will be found as accurate as is necessary in the art of sailing.

Thus if it were required to find the course a ship is to steer between two ports, whose longitudes and latitudes are known, we may use the following

RULE. To the logarithm of the number of minutes in the difference of longitude add the constant logarithm* −4,4015105, and to their sum the logarithm sine of the mean latitude, and let this last sum be S.

The Cotangent of the mean latitude being T, and the arithmetical mean between half the difference of latitude and its tangent being called m, and from the logarithm of T+m take the logarithm of T−m, and let the logarithm of their difference be D; then shall S−D be nearly the logarithm tangent of the angle, in which the ship's course cuts the meridian.

Note, We ought, in strictness, to use the ratio of tx+xR to tx−xR instead of T+m to T−m; but we substitute this last as more easily computed, and very little different.

EXAMPLE 1. Let the latitudes, on the same side of the equator, be 10° and 60°; then the middle latitude and its complement are 35° and 55°, and half the difference of the latitudes is 25°: and the difference of longitude being 110, the operation will stand as below.

* This constant logarithm contains the reduction of the diff. of longitude to parts of radius unity, and to Briggs's Modulus.

Log.

Log. 6600'. (in 110°) - - - 3.8195439
Constant log. - - - - - - - - 4.1015105
—1.9210544
Log. sin. 35°. - - - - - - —1.7585913

S = - - - - - —1.6796457

Again T' = 1.4281480
m = .4513202

Log. $\overline{T+m}$ (1.8794682) 0,2740350
Log. $\overline{T-m}$ (0.9768278) —1.9898180

Log. 0.2842170 = D = —1.4536500

S−D (= log. tangent 59°. 16') - - - - - - - - - = 0,2259957

agreeing to a minute with the solution by a table of meridional parts.

EXAMPLE 2. The rest remaining, let the difference of longitude be only 40°; then

Log. 2400' (in 40°) - - - 3.3802112
Constant log. - - - - - - —4.1015105
—1.4817217
—1.7585913

S = - - - - - - - - —1.2403130
D (as before) = — 1.4536500

S−D (= log. tang. 31°. 27'½) - - - - - - - - —1.7866630

agreeing to half a minute with computation by a table of meridional parts.

EXAMPLE 3. Let the difference of longitude be 40°; but the latitudes 56° and 80°;

And log. 2400 } + log. constant } = —1.4817217
Log. sin. 68° - - - = —1.9671659

S = - - - - - —1.4488876

T (tang. 22°) = .4040262
m = - - - - - - - - .2109980

Log T+m (= .6150242) —1.7888921
Log. T−m (= .1830282) —1.2625181

Log. - - 0.5263740 = D = —1.7212944

S'−D (= log. tangent 28°. 6') - - - - - - - - - - = — 1.7275932

wanting of the true answer no more than 1° 4'.

And in all cases that can occur, the error of this rule will be inconsiderable.

It is not meant, however, that it ought to take place of the easier and better computation by a table of meridional parts: but it was thought proper to shew, by some examples, how safely the map itself may be depended on in the longest voyages; provided it is sufficiently large, and the necessary rhumb-lines are exactly drawn.*

Part of N°. LXXV. by ~~[illegible]~~ Wm Mountaine, F.R.S. read Apr. 6. 1758.

If a map or chart was so constructed, as to shew the situation and true extent of countries, &c. primâ facie (if I may be allowed the expression), and yet retain all the properties, uses, and simplicity, of Wright's construction, it would be a truly great improvement; but this seems to be impossible.

ADENDA to Mr. Murdock's Paper. N.° LXXIII. (taken from p. 568. of Philos. Trans.)

If it is required, "to draw a map, in which the superficies of a given zone shall be "equal to the zone on the sphere, while at the same time the projection from the center is "strictly geometrical;" Take Cx to CM as a geometrical mean between CM and Nn, is to the like mean between the cosine of the middle latitude, and twice the tangent

* See Cotesii Logometr. Prop. 6.

of

of the semidifference of latitudes; and project on the conic surface generated by Xt. But here the degrees of latitude towards the middle will fall short of their just quantity, and at the extremities exceed it: which hurts the eye. Artists may use either rule: or, in most cases, they need only make CX to CM as the arc ML is to its tangent, and finish the map; either by a projection, or, as in the first method, by dividing that part of Xt which is intercepted by the secants thro' L and l, into equal degrees of latitude.

Mr. Mountaine justly observes, "that my rule does not admit of a zone containing N. and S. latitudes." But the remedy is, to extend the lesser latitudes to an equality with the greater; that the cone may be changed into a cylinder, and the rhumbs into straight lines.

Quantity of expansion of metals by heat. V. p. 140. and 155. & 157.

In No. 81 Vol. 47. of the Philos. Trans. for 1751 & 1752. p. 485. J. Ellicott, F. R. S. gives an account of many experiments about the expansion of different metals, made into bars of the same dimentions as near as possible, and found upon a medium, their several expansions by the same degree of heat to be as follows:

Gold	Silver	Brass	Copper	Iron	Steel	Lead
73	103	95	89	60	56	149.

Revolutions of a Top are more in vacuo, than in open air.

No. 56. Vol. 47 of the Philos. Trans. for 1751 & 1752. p. 352 is An account of an horizontal Top, invented by Mr. Serson, by Mr. James Short, F. R. S. wherein is, "By repeated trials it had been found, that the top, when set a-going in the open air, played or spun during the space of 35 minutes of time, from the instant of its being set up till it had lost the circular motion: but we found, that in the exhausted receiver it played or spun during the space of two hours 16 minutes (preserving a perfect horizontality for the space of 3/4 of an hour); and therefore, that the air has no share at all of the cause of its horizontality, and that the air is a great impediment to its motion".

Of Voluntary muscular motion. See Philos. Trans. Abr. Vol. X. Part 3, 4, p. 1114 to 1204.

No. XLVII. Of the Philos. Trans. for 1751 & 1752 p. 305. Vol. 47. — — — Observations and Experiments upon animal Bodies, digested in a philosophical Analysis, or inquiry into the Cause of voluntary muscular Motion, by Charles Morton, M. D. F. R. S.

Order, treated in.

Read Dec. 5. 1751. THE paper proceeds in the following order:

The Problem, or question proposed.

Observations and Experiments, illustrating the structure and use of the parts concerned.

Two Lemma's, with demonstrations concerning ~~automic~~ automatic or Involuntary motion.

Observations proving that the sensations, of which we make cognizance, are merely relative.

Observations, proving, that the ~~sensations~~ will has a power over sensation universally, to render it more or less acute.
Solution, or answer to the question, necessarily arising from the preceding facts.
Some short scholia.

Problem.

A muscle being given in its natural state, in a living animal body, it is asked how, or by what mechanical means, that muscle contracts, and is again relaxed, at the command of the will?

Observation illustrating the structure and use of the parts concerned.

Muscle, how composed.

Every muscle of an animal body is observed to be an instrument composed of fibres or lesser muscles, which are joined together every-where, by one common membrane or substance, called from its appearance, cellular. This substance, when it arrives at the surface of the muscle, becomes uniform, and makes one entire sheath for the whole muscle, or bundle of fibres, and renders it distinct from others.

Fibres, fleshy ones alone contract.

The constituent fibres in many muscles are observed to be partly fleshy, and partly tendinous; the one changing, or being continued, into the other, for the conveniency of insertion and motion. But the observation is universal, that the fleshy fibres alone contract in muscular motion, and that this contraction is always wave-like, or in alternate curls, from one extremity to the other, of a given fibre.

We constantly observe, in every muscle, numerous arteries, veins, and nerves. These are generally distributed together, or in the same course, by means of the connecting cellular substance, into every point of the fleshy fibres. Injections, and the knife of the anatomist, have followed them a great way, and reason completes the distribution, since you can nowhere wound the flesh of a muscle, but it shall bleed, and witness a sense of pain.

Therefore there is a circulation of blood, throughout the whole fleshy substance of a muscle: and further the muscle feels in every part.

Experiment.

In a living animal, if you tie the artery and vein, which principally belong to a given muscle, that muscle is disabled from acting at the command of the will. Steno, a Danish anatomist of the last century, performed this experiment upon the descending aorta, and thereby took away the use of all the lower limbs (vide Bergerum, p. 296) at once, and restored them at pleasure. Late anatomists have tried it upon lesser vessels, with the same constant success. (Vide Albini histor. muscul. p. 19.)

In a living animal, if you tie the nerve, that supplies a given muscle, that muscle is disabled from acting at the command of the will. This experiment is distinctly mentioned by Galen in his treatise on the muscles, and is approved by the trials of later anatomists. (Alb. p. 19.)

From these experiments it is clear, and generally agreed upon, that, in order to the performance of voluntary muscular motion,

besides the particular structure, there is required an absolute freedom of the blood-vessels, and the nerves.

Two sorts of muscular motion, viz. voluntary, & involuntary.

Muscular motion is observed to be voluntary, and involuntary. Of the first kind are almost all the muscles of an animal body; of the latter, the only complete instance is the heart. The first seems more complex than the latter, since, besides the motion, it implies an additional act of the will. Effects, that are less compounded, ought naturally to precede effects, that are more; these receiving light from the former, where both are homogeneous. For this reason, I have placed here two lemma's relating to automatic, or involuntary motion.

Lemma I.

Motion of the heart, how caused, viz by warm-blood.

The heart, in its natural state, in a living animal body, being given, its contraction proceeds solely from, or is mechanically caused by, the warm blood, flowing into and filling its fleshy substance in every part.

Experiment.

If this be denied, let the body of an animal be taken quickly after death, and let a warm mild fluid of any kind be injected gently into the heart, so as to fill it. When this is done, we shall see the heart quicken and contract, as in the life of the animal. This experiment was first distinctly mentioned by Peyer a Switzer (see a small treatise of his, printed anno 1682, at Amsterdam, and entitled Miraculum anatomicum in cordibus suscitatis) and is now known to every anatomist. But if this effect is thus constantly produced soon after death, how much more, when the animal is alive? And if, by the induction of any common fluid, with the bare addition of a warmth cognizable by our senses, how much more by the introduction of the living blood, an inimitable and wonderful fluid, and the immediate subject of the vital warmth?

If therefore it is granted, that we ought not to admit more causes of natural things than are real (and present for the occasion) and sufficient for explaining the appearances (a), and we must grant a rule, whose use is so obvious in the Newtonian, which is the philosophy of nature; we shall, I say, also grant, that the contraction of the heart, in its natural state, in a living animal body proceeds solely from, or is mechanically caused by, the warm blood, flowing into, and filling, its fleshy substance in every part. Which was to be proved.

Corollary.

Relaxations of the heart, caused, by the abscence of the warm-blood.

The subsequent relaxation admits no difficulty: for if the blood is the immediate mechanical cause of the contraction, when the blood is removed, the effect ceases.

Lemma II.

Contractions & relaxations of the muscles.

A muscle of voluntary motion, in its natural state, in a living animal body, being given, it will contract by the introduction of a warm mild fluid, into its fleshy substance in every part.

Experiment.

If this be denied, let the body of an animal be taken quickly after death, and the crural artery be pierced, and a warm mild fluid be injected into it: we shall then see the muscles, to which the artery belongs, quicken and contract, as if the living animal moved them. This experiment was known to Mr. Cowper, and is confirmed by Albinus (see Hist. Musc. p. 21.)

(a) Newton, R. 1.

But if this effect is constantly produced soon after death, how much more when the animal is alive?

Therefore a muscle of voluntary motion, in its natural state, in a living animal body, will contract, by the introduction of a warm mild fluid, into its fleshy substance, in every part: Which was to be proved.

Objection.

But here it may be objected, with some appearance of reason, that there is a warm fluid, the living blood, in every part of the fleshy substance of all the muscles, during the life of the animals; and yet it is a fact, that no muscle of voluntary motion contracts, but at the command of the will, morbid cases excepted. This objection comes close to the original question, and however reasonable it may seem, will quickly vanish before some common observations concerning the objects of sense in general, and their manner of operation upon the different organs, so far as it universally agrees.

Nerves, the immediate instruments of sensation, (v. p. 108) Which is merely relative.

We must first beg leave to make an easy postulatum, viz. that the nerves are the immediate instruments of sensation, though they are differently organized for the different senses.

<u>Observations</u>, <u>proving that the sensations of which we take cognizance are merely relative.</u>

It is a certain fact, that, in the several senses, the proper objects being supposed present, the sensation is entirely relative; or, in other words, that the presence of a powerful object always obliterates the present sensation of a weak object; and that the constant habitual presence of any one object, in the same given degree, produces no sensation at all.

Instances.

Thus we observe, that the light of the sun extinguishes the light of the stars; a stronger ~~taste~~ taste covers a weaker; the sound of a drum drowns an ordinary human voice; itching is banished by smart and pain; a weak scent, by one that is strong; cold, or a less degree of warmth, by heat, or a greater degree of warmth; and universally, our daily experience demonstrates to us, that every organ of sense, made familiar to a given degree of its object, affords no manner of sensation of the object in the given degree.

Thus it fares with the warm blood, which has constantly flowed through the whole minute substance of every muscle of voluntary motion in an animal body, from the time of their formation, or unfolding in the womb. And it is highly probable, that the quickening of the child in a woman is no other than the completion of that state, in which the blood begins freely to flow through, and to affect the instruments of voluntary motion; and till it becomes familiar to them, produces those frequent shudders, or general muscular contractions in the whole frame of the fœtus, which for a fortnight or more are the constant signs, that it has now obtained an animal life.

And here arises an apparent difference, though it will be found the greatest uniformity, between the muscles of voluntary and those of involuntary motion; and namely the heart; which being appointed to protrude the vital fluids during the life of an animal, has a short alternate remission of its contracting cause; and is thereby render'd capable of admitting a constant and necessary supply of labour and stimulus together, without any force, or contraction, to the natural order of the whole.

It

Merits of the cause of muscular motion.

It follows undeniably from what has been said, that if we can prove, that a given muscle of voluntary motion, does really feel an increase of the familiar warmth of its contained blood, or an equivolent, to rise and fall instantly at the command of the will, we shall then duly account for the subsequent motion. Or, more particularly, if we can prove, that the will has a direct power of heightenning, & increasing, and rendering more acute, the sense of any nerve, distributed to a given muscle, the same familiar positive degree of warmth in the contained blood will, to this more acute sense, appear to be proportionably heightened and increased, and the muscle (by lemma 2) will instantly contract, and continue in that state during the action of the will; allowing for a small feebleness, that will gradually arise from the gradual exclusion of the contracting cause, and from the blunting of this more acute, and, as it were, new sensation which yet, as we see, may be proportionably compensated, by the will, for a time, even to the destruction of the nerve, the blood-vessels, and indeed the whole organ, by a mortification, which has been known to succeed a long muscular contraction.

The Will has a power & does increase & heighten the sensation of the nerves.

Observations, proving, that the will has a direct power of rendering more acute the sensations of the nerves universally.

We know from daily experience, that the will hath a power over all the organs of sense, to heighten, or render acute, and again to relax them, their proper objects, in a reasonable dgree, being supposed present. And the same experience teaches us, that this power is greater or less, according to the more or less frequent use and exercise that is made of it. For it is obvious to ~~anyone~~, everyone, that any sound man is able to feel, to taste, to smell, to hear, and to see, more accurately when he pleases. And it is equally obvious and certain, that any one of these five senses, being exercised, with an uncommon degree of attention and industry, either from choise, or from necessity, arrives at an uncommon degree of accuracy, and perfection. Indeed it is entirely from use and exercise, that a child learns to distinguish at all between the several objects of a given sense, or, which are the same, between the several degrees, or modes, of its proper object.

All these particulars, being demonstrably true of every sense, that we can directly examine, the inference is very fair to the single sense (Lem. 2.) that we cannot directly examine; and, in truth, the induction in this case, is but one step below a complete experimental demonstration.

It appears therefore, that the will hath a direct power of heightening increasing, and rendering more acute, the sense or feeling in a given nerve, dispersed throughout the whole contracting substance of a given muscle, with all its gradations of accuracy and perfection. by repeated use and exercise.

Solution, or answer to the problem.

Muscular motion, how produced.

It follows therefore, that, a muscle being given, in its natural state, in a living animal body, the blood, which is present in every part of its contracting substance, and which, in effect, to the sense of the given muscle, (which is occasionally render'd more acute) puts on

an increased heat, and again lays it down at the command of the will is the immediate mechanical cause, by which the muscle does instantly contract, and is again relaxed, at the command of the will.

Therefore, a full solution is given to the question proposed: which was to be done.

Corollary 1.

Galen, wrong in his distinction of nerves.

Hence it appears, that muscular voluntary motion is performed merely as sensation (a), extremely acute, and under the nicest management of the will: which explains its velocity in a great measure.

Corollary 2.

Hence it appears, that the Galenic distinction of nerves, into nerves of sensation and nerves of motion, which greatly puzzles physiology, has no real foundation in an animal body.

A Short Scholium.

The solution, that is given to the problem, may be assumed in a philosophical synthesis, and the various appearances may thence be announced, as well in natural as in morbid cases; which again may be subject to a strict examination. Some trial has been made of this, and a surprizing agreement found: but the detail must be omitted. In the course of this inquiry, every foreign disquisition is industriously avoided, and such at this time would be a further question, Why blood, in a certain, or apparent, degree of heat, contracts a muscular fibre?

Philosophy, what. compare p. 205. &c. of Bp. Brown's procedure of human understanding. Edit. 3. where he argues very strongly against hypothesis & the mechanism of nature see p. 10. of this M. S. 1.

The business of natural philosophy is, to observe, and to note down facts, that are constant; and singling out those that are similar, to collect their proper universal, by a fair and regular induction; and to acquiesce in this, till a new collection of constant and similar facts affords an higher universal, and leads nearer the first cause.

(a) Hartley Conjectura de sensu, &c.

October 16, 1751.

Of artificial Magnets. V. p. 125.

N.° VI. (Of the Philos. Trans. for 1751 & 1752. Vol. 47. p. 31.) A Method of making arificial Magnets without the use of natural ones; communicated to the Royal Society by John Canton, M. A. & F. R. S. To which is prefixed the Presidents Report.

Read Jan. 17. 1750

Result of experiments upon the strength thereof.

The first 3 pages contain what the president saw Mr. canton perform, out of which I gathered, that a bar of steel weighing 1¾ oz. Troy lifted 28. oz troy. also, 2 large bars, each ½ inch square & 10½ in length weighing 10. oz. 12 Pwts, one of them, by one of its ends, lifted 79. oz. 9 Pwts. Moreover, a semicircular steel magnet, weighing 1. oz. 13 Pwts, lifted, by both ends, an iron wedge of 90. oz troy. then follows,

He (the president) had likewise been told by Mr. Canton, at the same time, in what manner the virtue might readily be taken away from any of his bars, which experiment he also

had

had also seen him put in practice. And that Mr. Canton had moreover changed in his presence the poles of a natural loadstone, by placing it in an inverted direction, between the contrary poles of two of his large bars, laid down at some distance from each other, in the same strait line continued: and that he had even performed this, without touching the stone with either of the bars, and only by placing it, in the manner just mentioned, between their poles, at the distance of about a quarter of an inch from either of them.

A Method of making Artificial Magnets without the use of, and yet far superior to, any natural ones.

To make artificial magnets.

Procure a dozen bars, six of soft steel, each three inches long, one quarter of an inch broad, and one twentieth of an inch thick, with two pieces of iron, each half the length of one of the bars, but of the same breadth and thickness; and six of hard steel, each five inches and an half long, half an inch broad, and three-twentieths of an inch thick, with two pieces of iron of half the length, but the whole breadth and thickness of one of the hard bars: and let all the bars be marked with a line quite round them at one end.

Step -- 1.

Then take an iron poker and tongs (*) (Fig. 2.) the larger they are, and the longer they have been used, the better; and fixing the poker upright between the knees, hold to it near the top one of the soft bars, having ~~...~~ its marked end downward, by a piece of sewing silk, which must be pulled tight with the left hand, that the bar may not slide: then grasping the tongs with the right hand a little below the middle, and holding them nearly in a vertical position, let the bar be stroked by the lower end, from the bottom to the top, about ten times on each side, which will give it a magnetic power sufficient to lift a small key at the marked end: which end, if the bar was suspended on a point, would turn toward the north, and is therefore called the north pole, and the unmarked end is, for the same reason, called the south pole of the bar.

Step. -- 2.

Four of the soft bars being impregnated after this manner, lay the other two (Fig. 3.) parallel to each other, at the distance of about one-fourth of an inch, between the two pieces of iron belonging to them, a north and a south pole against each ~~other~~ piece of iron: then take two of the four bars already made magnetical, and place them together, so as to make a double bar in thickness, the north pole of one, even with the south pole of the other; and the remaining two being put to these, one on each side, so as to have two north and two south poles together, seperate the north from the south poles at one end by a large pin, and place them perpendicularly with that end downward, on the middle of one of the parallel bars, the two north poles towards its south, and the two south poles towards its north end: slide them backward and forward three or four times the whole length of the bar, and removing them from the middle of this, place them on the middle of the other bar as before directed, and go over that in the same manner; then turn both the bars the other side upward, and repeat the

(*) Or two bars of iron.

former

former operation: this being done, take the two from between the ~~pieces~~ pieces of iron, and placing the two outermost of the touching bars in their room, let the other two be the outermost of the four to touch these with: and this process being repeated till each pair of bars have being touched three or four times over, which will give them a considerable magnetic power, put the half dozen together after the manner of the four (Fig. 4.) and touch with them two pair of the hard bars, placed between their irons at the distance of about half an inch from each other: then lay the soft bars a side; and with the four hard ones let the other two be impregnated (Fig. 5.) holding the touching bars apart at the lower end near two tenths of an inch, to which distance let them be seperated after they are set on the parallel bar, and brought together again before they are taken off: this being observed, proceed according to the method described above, till each pair have been touched two or three times over. But as this vertical way of touching a bar will not give it quite so much of the magnetic virtue as it will receive, let each pair be now touched once or twice over, in their parallel position between the irons (Fig. 6.) with two of the bars held horizontally, or nearly so, by drawing at the same time the north of one from the middle over the south end, and the south of the other from the middle over the north end of a parallel bar; then bringing them to the middle again without touching the parallel bar, give three or four of these horizontal strokes to each side. The horizontal touch, after the vertical, will make the bars as strong as they can possibly be made: as appears by their not receiving any additional strength, when the vertical touch is given by a greater number of bars, and the horizontal by those of a superior magnet power. This whole process may be gone thro' in about half an hour, and each of the large bars, if well hardened (*), may be made to lift twenty eight troy ounces and sometimes more. And when these bars are thus impregnated, they will give to an hard bar of the same size, its full virtue in less than two minutes: and therefore will answer all the purposes of magnetism in navigation and experimental philosophy, much better than the load stone, which is well known not to have sufficient power to impregnate hard bars. The half dozen being put into a case (Fig. 7.) in such a manner, as that two poles of the same denomination may not be together, and their irons with them as one bar, they will retain the virtue they have received: but if their power should, by making experiments, be ever so far impaired, it may be restored without any foreign assistance in a few minutes. And if, out of curiosity, a much larger set of bars should be required, these will communicate to them a sufficient power to proceed with, and they may in a short time, by the same method, be brought to their full strength.

Step -- 3. Step . 4. Step -- 5. Step -- 6. Strength of these bars. how to put them up. To harden Iron.

(*) The smith's manner of hardening steel, whom I have chiefly employed, and whose bars have constantly proved better than any I could meet with beside, is as follows: having cut a sufficient quantity of the leather of old shoes into very small pieces, he provides an iron pan, a little exceeding the length of a bar, wide enough to lay two side by side without touching each other or the pan, and at least an inch deep. This pan he nearly ~~fills~~ half-fills with the bits of leather, upon which he lays the two bars, having fastened to the end of each a small wire to take them out

by: he then quite fills the pan with the leather, and places it on a gentle flat fire, covering and surrounding it with charcoal. The pan being brought to somewhat more than a red heat, he keeps it so about half an hour, and then suddenly quenches the bars in a large quantity of cold water. 100

From the Philos. Trans. Vol. 47 for 1751 & 1752. p. 126.

XVII. A Letter from the Secretary of the Royal Academy of Sciences in Sweden, to Cromwell Mortimer, M.D. et F. R. Sec. concerning the variation of the magnetic needle.

Celeberrimo Domino Doctori, et Societatis Regiæ Londinensis Secretario, Cromwello Mortimer, S. P. D. Petrus Wargentin, Acad. Reg. Scient. Sueciæ Secretarius.

The Northern lights cause a variation of the mgnetic needle.

Read Feb. 21. 1750. OBIIT ante paucos menses secretarius Academiæ Regiæ Scientiarum Sueciæ, vir in mathematicis scientiis versatissimus, D. Petrus Elvus: cui, ex decreto academiæ, ego mox suffectus secretarius, muneris mei esse judicavi, commercium literarium cum exteris societatibus, academiis, et viris eruditis, instituere, cum persuasissimus sim ejusmodi literatorum commercia plurimum ad scientiarum incrementum facere.

** Ut aliquid ad scientias pertinens tibi impertiam, paucis narrabo de observatis a me nuper variantibus quotidie paullulum, sed sæpe admodum turbatis, declinationibus acus magneticæ.

Halleius vestras dudum suspicatus est, esse quoddam inter lumen boreale et acum magneticam commercium. Id certissimis experimentis et observationibus evicerunt jam aliquot annos Celsius atque Hiorterus, astronomi apud nos, dum viverent, celebres, qui sæpissime animadverterunt, acum magnopere turbatam atque inquietam esse, quoties lumen boreale ad zenit, vel ad plagam cœli meridionalem ascendit, ita quidem, ut declinatio videretur sequi motum luminis, et intra pauca temporis minuta totos tres et quatuor gradus aliquando variare. Res fide major mihi initio visa est. Meis oculis tam mirum phænomenon notare cupiebam. Cum itaque mihi traderetur acus, pedem Suecanum longitudine æquans, ab opifice nostro ingeniosissimo D. Ekstrom confecta, agilissima; mox, ineunte Februario hujus anni, cœpi annotare illius declinationes; quas statim quotidie variantes deprehendi, prout Grahamus, Celsius, etc. antea observaverant, ea videlicet lege, ut acus ab hora septima matutina ad secundam post meridiem, ab oriente ad occidentem magis magisque discedat, interdum tertiam vel quartam partem unius gradus. Post horam secundam iterum revertitur ad octavam vespertinam, usquedum eundem fere situm attigerit, quem hora octava matutina. Per totam noctem fere quieta esse solet, saltem ~~non~~ nisi parum circa mediam noctem

noctem abit ad occidentem, mox ineunte mane reditura. Hæc diurna variatio nunquam fallit, set constans et fere regularis est, nisi lumen boreale impediat.

Cum acus hoc modo, a die Februarii ad 15m circa septimum gradum declinationis(*) occidentalis vaga esset quotidie, eluxit, die 15°, lumen boreale, non tamen admodum vividum. Magna cum voluptate percepi, acum mox affici, ut intra 10 temporis minuta, circa horam decimam vespertinam, abiret 20' ad occasum, et intra alia decem minuta rediret et descenderet 37' ad ortum. Cessante lumine acquievit acus. Postro die insignis contigit turbatio, ideoque ipsas observationes citare non ingratum tibi esse judico, pro tota ista die.

Tempus h '	Declinat ac. ° '	Tempus h '	Declin. acus. ° '
8 0' a.m	7 0'	10 56 p.m.	7 1
10 0	7 4	11 6	6 25
12 0	7 10	11 10	5 51
2 0 p.m	7 15	11 19	6 43
4 0	7 11	11 22	6 26
8 0	7 2	11 26	6 42
9 0	6 50	11 37	5 23
10 0	6 8	11 45	5 0
10 5	5 31	11 58	4 35
10 8	5 47	12 0	5 0
10 15	5 29	12 15	6 30
10 30	6 0	12 27	6 22
10 46	7 26	12 35	6 55

Per totam hanc noctem vix aliquo momento quievit acus; sed omnibus aliis rebus quietis, me solo tacitis passibus acum invisente, nullo ferro admoto, vagabatur hinc inde quasi vertigine correpta. Lumen boreale hac nocte fuit in plaga meridionali splendidum et vivacissimum, interdum per totum cœlum se rapidissimo motu diffundens: sed ego intentus acui, non satis luminis apparentias observare potui. Sequentibus diebus admodum quieta mansit acus, ut et variationes diurnæ solito minores fuerint. At die 28 Februarii, novo erumpente lumine boreali insigniore. Sentiit id acus, quæ cœpit vacillare hora post meridiem quarta, sole adhuc splendente: unde intellexi nos proxima nocte visuros lumen boreale. Nec fefellit eventus. At locus non permittit ipsas huc transcribere observationes: sufficit dixisse, quod vacillaverit acus inter 6° 50' and 9° 1'. Per totum mensem Martium nihil præter consuetas diurnas digressiones unquam animadverti, ne 6' quidem, licet lumen boreale tum conspiceretur, sed debile et quietum prope horizontem borealem.

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* Hæc declinatio non est vera et media hoc tempore Holmiæ, sed aliquanto minor vera. At hac occasione non quæsivi veram declinationem, sed ejus tantum variationem.

At

At die secunda Aprilis, ruptis induciis, rursum exarsit lumen, acui infestans, idque per duos Integros dies, die noctuque pariter, quantum ex acu cognovi; nam illa continuis agitata motibus fuit, licet lumen non nisi noctu observari posset. En præcipuas observationes.

	Tempus	Decl. ac.
April 2,	2^h 40' p.m.	7° 7'
	4 20	7 10
	5 22	7 21
	10 31	5 31
	10 55	5 57
	11 34	6 27
	11 52	6 0
	12 3	4 56
	12 8	5 27
	12 18	6 34
	12 21	6 18
	12 28	6 37
	12 45	6 22
April 3,	7 0 a.m.	7 5
	10 15	6 48
	10 49	7 15
	3 30 p.m.	7 25
	4 43 p.m.	8 55
	4 49	9 55
	5 4	8 7
	5 11	8 38

	Tempus	Decl. ac.
April 3,	5^h 27'	8° 10'
	5 37	8 37
	6 9	7 55
	7 8	7 22
	10 25	7 10
	10 43	8 29
	10 54	7 1
April 4,	7 14 a.m.	6 29
	8 5	5 54
	9 40	6 53
	9 50	7 22
	10 17	7 0
	10 53	7 5
	1 29 p.m.	7 11
	2 19	7 19
	2 46	6 29
	4 50	7 16
	6 52	7 2
	8 0	6 58
	10 15	6 55
	11 3	6 50

Variavit itaque acus intra diem unum plus quinque integris gradibus.

Die 20 Aprilis, cum toto die vehementer plueret, acus tamen turbata fuit, maximæ variationes erant duorum graduum. Non conquievit acus ante meridiem diei sequentis.

Sed te jam nimis diu detinui, vir æstumatissime; ideoque heic subsistens me tuæ amacitiæ tuoque favori etiam atque etiam commendo. Vale.

Stockholmiæ, calendis Maii
1750.

From the Philos. Trans. Vol. 49 Part 1. for 1755.

General Rules for Isoperimetrical problems, of all orders. see p. 84.

II. An Investigation of a General Rule for the Resolution of Isoperimetrical Problems of all Orders. By Mr. Thomas Simpson. F. R. S.

Read Jan.ʸ 9. 1755. THE different species of problems comprehended under the name of Isoperimetrical ones, are of much greater extent than the name imports; since, not only the determination of the greatest areas and solids, under equal perimeters or bounds (whence the name is derived), but whatever relates to the Maxima and Minima of quantities depending on a line, space or body, whereof the figure is unknown, is,

is, by mathematicians, included under that denomination.

But notwithstanding the usefulness and great extent of this subject, nothing (that I know of) had been done thereon farther than the resolution of certain particular cases (such as finding the line of swiftest descent, and the solid of least resistance), 'till the celebrated mathematician M^c Laurin in his treatise of fluxions, gave the investigation of an elegant and very easy method, whereby the principal problems belonging to the first order may be solved.

The paper I have now the honour to lay before the Society contains farther improvements on this subject: as it is by far more general than any thing yet offered, and is drawn up with a view to obviate the difficulties attending the resolution of a very intricate kind of problems, and thereby to open an easy way to some very interesting inquiries in natural philosophy, I cannot doubt of its meeting with a favourable reception.

Lemma. I.

Fig. 9. At any given points D, G, I, L, in a right line AL, supposing perpendiculars to be erected; and from any other given points c, f, h, k, at equal distances (cD', fG', hI', kL',) from the said perpendiculars, respectively, conceive right-lines cd, fg, hi, kl, to be drawn, to terminate somewhere in the said perpendiculars; let Q, R, S, T, denote any quantities expressed in terms of AC, cD', and D'd, (independent of Cc) and Q', R', S', T', as many other quantities affected in the very same manner with AF, fG', and G'g; and let Q'', R'' S'' T'', and Q''', R''', S''', T''' be quantities, still, expressed in the same manner, in terms of AH, hI', I'i, and AK, kL', L'l, respectively: 'tis proposed to find an equation expressing the relation of the indeterminate perpendiculars D'd, G'g, I'i, L'l, so that the quantity $Q+Q'+Q''+Q'''$ may be a Maximum or Minimum, at the same time that the values of the other quantities $R+R'+R''+R'''$, $S+S'+S''+S'''$, and $T+T'+T''+T'''$ are given, or continue invariable.

Put $D'd=\alpha$, $G'g=\beta$, $I'i=\gamma$, $L'l=\delta$; and let the fluxion of Q (supposing α variable) be denoted by $q\dot{\alpha}$, that of R, by $r\dot{\alpha}$, &c. &c. then, since (by the nature of the proposition) the fluxion of $Q+Q'+Q''$ Q''', as well as those of $R+R'+R''+R'''$, $S+S'+S''+S'''$, &c. must be equal to nothing, we therefore

$$\text{have}\begin{cases} q\dot{\alpha}+q'\dot{\beta}+q''\dot{\gamma}+q'''\dot{\delta}=0\\ r\dot{\alpha}+r'\dot{\beta}+r''\dot{\gamma}+r'''\dot{\delta}=0\\ s\dot{\alpha}+s'\dot{\beta}+s''\dot{\gamma}+s'''\dot{\delta}=0\\ t\dot{\alpha}+t'\dot{\beta}+t''\dot{\gamma}+t'''\dot{\delta}=0\end{cases}$$

In order now, to exterminate the fluxions $\dot{\alpha}$, $\dot{\beta}$, $\dot{\gamma}$, $\dot{\delta}$, let these equations be respectively multiplied by 1, e, f, g, (yet unknown), and let all the products thence arising be added together, whence will be had $\overline{q+er+fs+gt}\times\dot{\alpha}+\overline{q'+er'+fs'+gt'}\times\dot{\beta}+\overline{q''+er''+fr''+gt''}\times\dot{\gamma}+\overline{q'''+er'''+fs'''+gt'''}\times\dot{\delta}=0$.

Make now, $q'+er'+fs'+gt'=0$

$$q''+er''+fs''+gt''=0$$
$$q'''+er'''+fs'''+gt'''=0$$

From whence (there being as many equations as quantities, e, f, g, to be determined), the values of these quantities will be always given in terms of q', r', s', &c. that is, e, f, g, will always be represented by

by quantities depending on q', r', s', &c. (or on AF, G'g, &c.) exclusive of q, r, s, t, (or of AC and D'd), which have nothing to do in these last equations.

But, because all the terms of the equation $\overline{q+er+fs+gt}\times\dot{\alpha}+\overline{q'+er'+fs'+gt'}\times\beta$, &c. $=0$, after the first $(\overline{q+er+fs+gt}\times\dot{\alpha})$ do vanish (by their coefficients being made equal to nothing), it is evident that $q+er+fs+gt$ must also be $=0$: which is an equation expressing the general relation of AC, cD', and D'd, with regard to the other ~~quan~~ proposed quantities AF, fG', G'g, &c. whereon the coefficients e, f, g, depend: and this relation will, evidently, continue the same, at whatever distances from the line AI, the points c, f, h, k, are taken, as these distances have nothing to do in the consideration, all the propos'd quantities (as well the Q's as R's, &c.) being (by hypothesis) express'd in terms intirely independent thereof.

Lemma II.

Fig. 10. Upon a given right-line BI, suppose perpendiculars Bb, Cc, Dd, &c. to be erected at equal distances: and upon the same line BI, as a base, suppose a polygon Bbcdefghikl I. to be constituted, having its angular points b, c, d, &c. posited in the said perpendiculars; let y denote the distance of any of these perpendiculars (Cc, Dd, &c.) from any given point A, in IB produced; and, supposing bC', cD', dE', &c. to be drawn parallel to AB, let the base of any of the little triangles bC'c, cD'd, &c. be represented by $\dot{y}$, and the perpendicular corresponding by $\dot{x}$ ($\dot{y}$ being given, or the same, in every triangle, and $\dot{x}$ indeterminate): then, supposing Q, R, S, T, to denote any quantities express'd in terms of y, $\dot{y}$, and $\dot{x}$, it is proposed to find an equation exhibiting the general relation of the quantities y, $\dot{y}$ and $\dot{x}$, so that the sum of all the $\dot{y}$ Q's (resulting from the several triangles) may be a Maximum or Minimum, at the same time that the sums of all the $\dot{y}$R's, $\dot{y}$S's, &c. are given quantities.

Because the values of the quantities $\dot{y}$Q, $\dot{y}$R, $\dot{y}$S, $\dot{y}$T, depending on the different triangles bC'c, cD'd, &c. are supposed to be no-ways affected by the distances (Bb, Cc, &c. of the bases of those triangles, from the base BI of the polygon, it is evident, that those values may be changed, by altering the species of one, or more, of the said triangles at pleasure, without any-ways affecting the values depending on the other triangles: for another polygon IB123 45, &c. may be so described as to have all its sides, respectively, parallel to those of the former, excepting only those (23, 56, 78, 910) you would have to be different: so that the whole variation in the several sums (whether of the $\dot{y}$ Q's, $\dot{y}$R's, or $\dot{y}$S's, &c.) will depend intirely upon the difference of the particular triangles 2q3, cD'd; 5t6, fG'g, &c. assigned.

Since, therefore, the values of they $\dot{y}$Q's, $\dot{y}$R's, $\dot{y}$S's, &c. may be varied, at pleasure, by altering the species of any number of corresponding triangles (2q3, cD'd; 5t6, fG'g; 7w8, hI'i; 9y10, kL'l), while the other triangles, and the values depending on them, remain the same, it is manifest, that, when the sum of the $\dot{y}$Q's, answering to all the triangles, is a Maximum or Minimum, the sum of any number of them, taken at pleasure (other things remaining the same), will likewise be a Maximum or Minimum

and

and, consequently, that the sum of as many Q's will, at the same time, be a Maximum or Minimum, because $\dot{y}$ is every-where the same, or a constant quantity.

Hence, if the construction of the preceding Lemma be retained (supposing all the Q's, R's, S's &c. to be here expressed as before, in terms of AC, cD', and D'd, &c.) it is plain that the sum of all the Q's, (or of the $\dot{y}$Q's), depending on the said particular triangles (and consequently of all the the $\dot{y}$Q's in general), will be a Maximum or Minimum, when the general relation of y, $\dot{y}$, $\dot{x}$, (or of AC, cD', D'd,) is expressed by the same equation $q+er+fs+gt=0$, there determined: in which q, r, s, t, represent the fluxions of Q, R, S, T, divided by that of $\dot{x}$ ($=\alpha=$ D'd), and wherein the coefficients e, f, g, will be constant quantities; because it is proved that their values depend intirely on the triangles fG'g, hIi, kL'l, which remain the same, let the perpendicular (or ordinate) Cc be taken at what distance you will from the given point A; that is, let y stand for which you will of the distances AB, AC, AD, &c. Q. E. I.

Corallary.

If the sides of the polygon bcdefgh, &c. be diminished, and their number increased *in infinitum*, the sum of all the $\dot{y}$Q's will (it is well known) be expressed by the fluent of $\dot{y}$Q; the sum of all the $\dot{y}$R's, by the fluent of $\dot{y}$R, &c. whence it follows, that, to have the fluent of $\dot{y}$Q (answering to a given value of y) a Maximum, or Minimum, and the fluents of $\dot{y}$R, $\dot{y}$S, &c. at the same time, given quantities, the relation of y, $\dot{y}$, and $\dot{x}$, must be defined by the equation $q+er+fs+gt=0$, above exhibited; q, r, s, &c. being the respective fluxions of Q, R, S, &c. divided by that of $\dot{x}$, (or $\ddot{x}$); this quantity $\dot{x}$ or $\dot{x}$, (in finding the said fluxions) being, alone, considered as variable. Hence we have the following

GENERAL RULE.

For the resolution of Isoperimetrical problems, of all orders, take the fluxions of all the given expressions (as well that respecting the Maximum, or Minimum, as of the others whose fluents are to be given quantities), making that quantity ($\dot{x}$) alone variable, whose fluent (x) enters not into the said expressions; and, having divided every-where by the second fluxion ($\ddot{x}$), let the quantities hence arising, joined to general coefficients, 1, e, f, g, &c. (whose values will depend on the values given, and may be either positive or negative), be united into one sum, and the whole be made equal to nothing; from which equation the true relation of $\dot{x}$ and $\dot{y}$, and of x and y, will be given, let the number of restrictions be what it will.

For an example of the general ~~Rule~~ Rule here laid down, let the fluxions given be $\frac{y\dot{x}^3}{\dot{y}\dot{y}}$, and $\dot{x}$; the fluent of the former, corresponding to any given value of y, being to be a Minimum, and that of the latter, at the same time, equal to a given quantity. Here, taking the fluxions of both expressions (making $\dot{x}$, alone, variable), and dividing by $\ddot{x}$, the quantities resulting will be $\frac{3y\dot{x}\dot{x}}{\dot{y}\dot{y}}$ and 1; so that, in this case, we

we have $\frac{3y\dot{x}\dot{x}}{\dot{y}y} + e = 0$, and therefore $\dot{x} = a^{\frac{1}{2}}y^{-\frac{1}{2}}\dot{y}$ (supposing $a = -\frac{1}{3}e$). From whence, by taking the fluents, $x = 2a^{\frac{1}{2}}y^{\frac{1}{2}}$; or $x^2 = 4ay$, an equation answering to the common parabola.

If the abscisse of a curve be denoted by x, and the ordinate by y, it is known, that the several fluxions of the abscisse, curve-line, area, superficies of the generated solid, and of the solid itself, will be represented by $\dot{x}$, $\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}$, $y\dot{x}$, $2py\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}$, and $py^2\dot{x}$ respectively: if, therefore, the fluxions of these different expressions be taken as before (making $\dot{x}$, alone, variable), we shall get

$$1 + \frac{e\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}} + fy + \frac{gy\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}} + hy^2 = 0,$$ being a general equation for determining the relation of x and y, when any one of the said five quantities (viz abscisse, curve-line, area, superficies, or solid) is a Maximum or Minimum, and all, or any number of the others, at the same time, equal to given quantities; wherein the coefficients e, f, g, and h, may be either positive or negative, or nothing, as the case proposed may required. Thus, for example, if the length of the curve, only, be given, and the area corresponding is required to be a Maximum, our equation will become $\frac{e\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}} + fy = 0$, or $a^2\dot{x}^2 = y^2 \times \overline{\dot{x}\dot{x}+\dot{y}\dot{y}}$ (by making $a = -\frac{e}{f}$); whence $\dot{x} = \frac{y\dot{y}}{\sqrt{aa-yy}}$, and consequently $x = a - \sqrt{aa-yy}$, or $2ax - x^2 = y^2$; answering to a circle; which figure, therefore, of all others, contains the greatest area, under equal bounds.

If together with the ordinate (which, here, is always supposed given) the abscissa, at the end of the fluent, be given likewise, and the superficies generated by the revolution of the curve about its axis be a Minimum; then, from the same equation, we have $1 + \frac{gy\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}} = 0$: whence (making $a = -\frac{1}{g}$) $\dot{x}$ is found $= \frac{a\dot{y}}{\sqrt{yy-aa}}$; ~~which equation, being impossible when y is less than a~~ and, from thence, $x = a \times \text{hyp. log.} \frac{y+\sqrt{yy-aa}}{a}$; which equation, being impossible when y is less than a, shews that the curve (which is here the Catenaria) cannot possibly meet the axis about which the solid is generated; and, consequently, that the case will not admit of any Minimum, unless the first, or least given value of y exceeds a certain assignable magnitude.

When any, or all of the above-specified quantities are given, and the contempory fluent of some other expression, as $\overline{\dot{x}\dot{x}+\dot{y}\dot{y}}|^n \times y^m \times \dot{y}^{1-2n}$, is required to be a Maximum, or Minimum; the equation (by taking the fluxion of this last expression, and joining it to the former) will then be $\overline{\dot{x}\dot{x}+\dot{y}\dot{y}}|^{n-1} \times 2n\dot{x}y^m\dot{y}^{1-2n} + d + \frac{e\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}$,

$+fy + \frac{gy\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}} + hy^2=0$; which, when $m=1$, and $n=-1$, will be that defining the solid of the least resistance; and this, when the axis only is supposed to be given (without farther restrictions) will be expressed by $\overline{\dot{x}\dot{x}-\dot{y}\dot{y}}|^{-2} \times -2\dot{x}y\dot{y}^3+d=0$, or $2y\dot{y}^3\dot{x} = d\times\overline{\dot{x}\dot{x}+\dot{y}\dot{y}}|^2$; being the case, first considered by Sir Isaac Newton. — If both the length and the solid content be given, the equation will be $-2\dot{x}y\dot{y}^3\times\overline{\dot{x}\dot{x}+\dot{y}\dot{y}}|^{-2}+d+hy^2=0$; but if, besides these, the superficies is given likewise, it will then be $-2\dot{x}y\dot{y}^3 \times\overline{\dot{x}\dot{x}+\dot{y}\dot{y}}|^{-2}+d+\frac{ey\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}+hy^2=0$.

Thus, in like manner, by assuming $m=-\frac{1}{2}$, and $n=\frac{1}{2}$, we have $\frac{y^{-\frac{1}{2}}\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}+d+\frac{e\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}+fy+\frac{gy\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}+hy^2=0$, for the general equation of the curve of the swiftest descent: which, when e, f, g, and h, are, all of them taken equal to nothing, will become $\frac{y^{-\frac{1}{2}}\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}+d$; which is the case, considered by so many Others, answering to the cycloid. When the length of the arch described in the whole descent (as well as the values of x and y) is given, the equation will then be $\frac{y^{-\frac{1}{2}}\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}+d+\frac{e\dot{x}}{\sqrt{\dot{x}\dot{x}+\dot{y}\dot{y}}}=0$, or $\overline{e-y^{-\frac{1}{2}}}|^2\times\dot{x}^2=d^2\times\overline{\dot{x}\dot{x}+\dot{y}\dot{y}}$. And thus may the relation of x and y be determined, in other cases, and that under any number of restrictions.

The substance of N.° 42. of the Philos. Trans. Vol. 49. Part I. for 1755. p. 254.

Upon the nourishment of the Fœtus by Malcolm Fleming, M.D. of Brigg, in Lincolnshire.

The manner, not only of generation, the formation ~~of the ... of the embryo~~ of the embryo, & the various changes it undergoes, but even the nourishment of a mature fœtus is much disputed; and that, whether the fœtus in utero be nourished solely by the blood, which is transmitted to it through the umbilical cord; or whether it is likewise nourished in part by the liquor amnii, in which it swims? for the clearing up of which is laid down this necessary preliminary, in which "the writers on both sides either explicitly or implicitly agree, to wit, that if it be clearly made out, that the liquor amnii is naturally received into the mouth, stomach, and intestines of the fœtus, swimming in it; in that case we are to conclude, that the fœtus is in some part nourished by it. The whole tract of the alimentary passage abounds with ~~...~~ absorbent vessels in the fœtus, more than in the adult animal; and especially the small intestines have lacteals plentifully opening into them. The liquor amnii is concretable by heat, like the white of an egg; which characteristic in animal juices is, I belive, denied by none to be a proof of their alimentary nature. To such as will not grant this postulatum, if any such there be, this paper is not addressed. Contra negantem principia non est disputandum." Upon examining the intestines, rectum & anus, of a calf, come to full maturity, but brought forth dead, there were found in the anus an incredible quantity of meconium, formed into distinct scybala or balls, each stuck full of tough, thick, white hairs, some scores in each & some an inch or more in length; the skin was likewise white: from which is inferred, "that if hairs loosen'd from the skin of the fœtus, and floating in the liquor amnii, can find away into the intestines, and get entangled in the meconium, it

it is impossible but the liquor amnii must enter and pass through the whole alimentary passage along with them; as a fluid may certainly penetrate where hairs cannot."

The first dung of calves after they are brought forth; which cannot be any thing but meconium, was examined with the same success; but embryo's, of the cow-kind, afforded no such circumstances by reason of their not having hair sufficient to float in the liquor amnii; nor did those of puppies & colts by reason of their hair being so firm to the skin, as scarce to pull any off with the thumb & finger. These facts seem to decide the controversy, and incontestably prove, that the liquor amnii is in a constant natural way received into the mouth, stomach, & intestines, and therefore must contribute to the nutrition of the foetus. Aldes, (a feigned name, under which Slade, an Amsterdam physician, conceals himself) mentions these facts in his Epistola contra Harveium published in the first volume of the Bibliotheca Anatomica of Magnetus and Le Clerc. And Swammerdam both mentions the facts & draws the conclusion, in Biblia Naturæ p. 319.

The lungs of a new-born animal sinks in water.

"After cutting out the lungs & heart" of the above mentioned calf, "I clipped off a piece of the former with sharp scissars, about an ounce weight, or more, & threw it into a bason full of water. It quickly sunk to the bottom, and settled there. Immediately after, I blew into the remaining part of the lungs, through the trachea; and though I could by that means distend them very little, because the air flowed out readily through the cut bronchia, and therefore acted but faintly on the other parts; yet a piece about the same bigness with the first, clipped off in the same manner, and thrown into the same bason, constantly kept at the top."

Upon the Sensibility & Irritability of the several Parts of Animals. By Richd. Brocklesby. M.D. F.R.S.

V. the postulatum on p. 95.

The substance of N.° 38 of Vol. 49. Part I. of the Phil. Trans. for 1756. p. 240.

"The first experiment I propose to relate, was made by cutting four inches of a young lamb's skin, which covered the great tendon of the hinder leg, and is known to anatomists by name of the Tendo Achillis. This of course caused violent struggles, and other marks of the injury felt; and on touching the extremity of the skin, whilst united to other parts of the animal, it cried loud, urined, and voided its excrement, when I poured diluted spirit of vitriol upon the edges of the skin, that were fixed on the contiguous parts; but did not express much pain by irritating the raised skin, at the farthest extremity of its seperation, but an affusion of diluted spirit of vitriol. Nearer however to the fixed parts underneath, the sensation in the raised part of the skin continued much longer.

I then made the butcher cut into the tendon half way, and divide it upwards more than two inches, and attentively stood over the animal to watch his motions, and discover if there was any apparent pain: but whilst that was doing, I could discern none, nor any marks of sensation in the animal, whilst I handled and pulled the cut tendon, nor yet any on touching it with diluted spirit of nitre, and sharp acid spirit of vitriol; and what yet surprized me more, was to find the creature as insensible upon the tendon, as if it was a mere piece of glue, when I put a strong muria of sea-salt and nitre all over it; and after a very few minutes I laid the raised part of the tendon in its natural direction, upon the correspondent fixed part, and they were both exactly congruous; so that the loose part had not contracted itself, nor was at all shorter, after these repeated trials, than its correspondent fixed part. I then put the creature on its legs, to see whether it had suffered so much, that it could not use the leg; but it was found to walk, though favouring greatly that side where so much had been done; however, it walked fairly on all its legs. After about five minutes torment, the butcher ended all its pains, and I performed the same processes on a sheep just destined to be slaughtered, in which I found all the appearances as above mentioned.

I was

I was induced to make two other very cruel experiments on different animals by laying bare their ~~pat~~ patella's of the knees: having cut off all the skin round about, I then pricked and touched with the afore-mentioned escharotics the capsular ligaments of these joints, without discovering any tokens of pain thereby occasioned; but as soon as the sharp fluids had spread over the surface so as to reach the extremity of the skin, the creature underwent as much pain as cutting before had caused.

I desired the butcher to take off as much skin from the forehead, as was necessary to perform the operation of the trepan; and before I began to apply the instrument to the sheep's forehead, I vellicated the pericranium with the end of a knife, but could not observe the membrane sensible, or thereby thrown into contractions; and when the operation was over, and the bone taken from the Subjacent dura mater, I poured on this membrane dulcified spirit of nitre, and diluted spirit of vitriol, and powdered common salt, but without perceiving any agitations whatsoever, brought on by these substances acting upon these living parts; though in some creatures I am dubious, whether sea-salt and nitre in powder did not create in some sense, though no manifest contractions of the dura mater.

But every muscular part, which I cut while the animals were alive, discovered little sensibility of pain; though great propensity to irregular spasms of the fibres: and the muscles upon the thorax, and especially the carneæ columnæ of the heart, retained irritability last of all other muscular parts, even till long after the animal's expiration.

I laid the pungent liquors and salts, as above, upon various parts of the animal, yet alive; as upon the fat, cellular membrane of the neck, leg, and other parts within the skin, the liver, pancreas and spleen, and could not find them endowed either with remarkable sensibility or irritability; nor had the bladder any remarkable symptoms of irritability, farther than might be occasioned by its muscular fibres; though the well known symptoms of the calculus shew its great sensibility.

I tried the effects of a strong aqueous solution of opium upon the irritated parts of muscular fibres, but could not perceive an opiate manifestly to compose these spastic motions of the parts, as Haller (who mentions most of these experiments in his late treatise entitled, A Dissertation upon the Irritability of animal fibres.) alleges they do: tho' in some trials I fancied there were grounds for such a conclusion. However this is no argument against the internal use of opiates, where the solids are greatly irritated.

I must add one more experiment, which I made upon the intestines of a lamb: after I had taken them from the carcase, I poured diluted spirit of vitriol on them, as well as several other pungent substances; and upon the touch of all of them, the intestines renewed their contraction, which before had totally ceased, and surprized me with a motion almost as strong as is found in the process of chylification; and this continued till the external cold had indurated and stiffened the fatty membrane of the omentum.

These were some of many experiments of a like nature, which the importance of these facts in daily practice of medicine required to ascertain, or reject; and from the result of my repeated trials, I am induced to coincide with most of the conclusions drawn by D.rs Haller, Castell, and Zimmerman; that no part is sensible but the nerves only, and that some parts are irritable without sensibility accompanying them in any great degree; whilst others are altogether without sense, at the same time that they are incapable of being irritated at all."

New Broad-street

June 19, 1755.

A Description of a new Micro=meter, invented in the year 1761. By B. Talbot, Teacher of the Mathe=matics at Cannock, Staffordshire.

I have considered this micrometer at p. 128.

Figure 12. is a section of it, supposed to be cut through at the ~~fund~~ focus of the object-glass; in which **ab** is a male screw, one half of whose threads are what I call a right-hand screw, and the other half a left-hand screw, and both halves having the same number of threads in an inch. **cc** are two female screws, exactly fitting the male ones, and part of the brass being filed away, they make the two standards for fixing the very fine wires or hairs **gg**, which are fastened by a small hole in the blocks **cc**, and at top by the small screws **hh**. — **AB** and **AB** are two brass plates (about an inch broad, and two long) which contain, or hold, the micrometer screw **ab**; and these plates are fixed, by two screws, to a brass bar **dd**; in this bar is a small groove, in which the bottom of the blocks, or standards, **cc**, (being filed thin) are fitted, so as to slide tight along and keep the standards from shaking. At **a** is a little brass knob with a square hole in it, to fit the small square end of the micrometer-screw at **a**, and serves to turn the said screw round backwards or forwards, by which means the standards, **cc**, and consequently the hairs **gg**, recede from, or approach to each other with an equal velocity, and, if continued, will meet exactly in the axis of the telescope, or center of the field of view. At the bottom of the little knob **a** is fixed a small steel index or finger, moving round a circle drawn on one of the plates **AB**, this circle is divided into sixty equal parts, and figured 10, 20, &c. to $\frac{60}{0}$.

And near the other end of the screw **ab** is fixed into it a small stud or pin **e**, which moves the wheel **f** containing 30 teeth; on the axis of this wheel is fixed ~~an~~ index **i** moving round a circle drawn on the other plate **AB**, and divided into thirty equal parts, and figured 5, 10, &c. to $\frac{30}{0}$.

Now, these indices always shew how many revolutions, and parts, of the micrometer-screw the hairs are asunder, for while the screw makes ~~an~~ revolution the index **a** moves over 60 divisions; but the index **i** moves over but one. So by having the number of threads of the screw in an inch, and the focal length of the object-glass made use of, the angle becomes known, and so a table may be made to shew the angle answering any number of revolutions or parts thereof, almost by inspection. Or it will be easy to compute the focal length of an object-glass, that one minute may exactly correspond to one revolution of the screw; and then their indexes will always shew, by inspection, the minutes and seconds contained between the hairs of the micrometer.

~~[illegible]~~ See p. 129.

In my micrometer there is very near 64 threads in an inch, viz. 30 revolutions = ,94 parts of an inch, therefore as tangent $15' : \frac{,94}{2} ::$ rad. : 107,7 inches, or 9 feet, nearly, the focal length of an object-glass that will shew minutes and seconds by inspection of the indexes.

~~[illegible]~~

Fig. 13. contains a perspective view of the micrometer (diminished nearly to half its size,) as fixed in the frame, or eye piece, of the refracting telescope, which in mine is made of wood, and turned round at each end, but left square in the middle, as in the figure. In the middle of this square part, is sawed a notch, just wide enough to contain the brass bar <u>dd</u>, and standards **cc** (mentioned in figure 12.) and so deep as to permit the bar to lie level with the square part of the frame, and the brass plates being of the same length and breadth as the square part of the frame, fit close to the sides thereof, when the micro=meter is slipped down into the slit or notch, and are fastened by two screws one of which is seen at <u>k</u>, the other cannot be seen in this view. — The eye-piece unscrews at <u>ll</u>, in order to take out the eye=glass to clean, &c. there may also be a screw at **m**, **m**, to screw it to

the tube of the telescope, or it may be fixed by glewing the tube into it as is done in mine.

Having described the mechanism of this most simple, but accurate instrument, I shall point out a few of the uses and advantages this micrometer has over any other I have yet made use of, or seen described.

Planets, their diameters observed.

1°. In observing the planets diameters, it is well know to such as have been used to Kirchius's micrometer (of two screws moving in a ring and meeting in the center of the field of view) the observations are momentary; but with mine it will be found quite otherwise, for having adjusted the hairs nearly to the planet's Diameter, and turned the tube with the michrometer in such a manner that the planet may pass exactly between, just touching each hair thro' the whole field of the telescope, the observation may be improved, or corrected, for the space of a minute and an half, or two minutes, and consequently the diameter taken with the utmost ease and exactness.

Occultations, an advantage in observing them.

2°. In the occultations of fixed stars, &c. if one of the hairs in my micrometer be made to bisect the moon at right angles to the cusps, or nearly ~~so~~, and the other to touch the star near the point of immersion, it will also cut the other edge of her disk in the point of emersion; for want of knowing which, the observer may miss the moment of emersion. See fig. 14, and 15. where ab is the bisecting line, c the point of immersion, and d that of emersion.

Planets, their R. A. & Decl.n observed.

3.° When any of the ~~known~~ planets are so near to a known fixed star as to be both within the field of the telescope, the difference of right ascensions and declinations are found thus, turn the micrometer and ajust the screws in such a manner that the star moving along one hair, the planet may move along the other, then will the micrometer shew their difference of declinations, and turning the tube of the micrometer $\frac{1}{4}$ round, and adjusting the hairs so that when the star touches one, the planet may touch the other hair, then will the micrometer shew the difference of right ascentions, see fig. 16. in which a✶ and ♂b shew the positions of the hairs in the difference of the declinations; and c✶ and ♂d in the difference of right ascentions. Note, this is the true difference of right ascention if the planet be in or very near the equinoctial, otherwise must be increased in proportion of the co-sine of the planet's declination to the radius. — I might have added more, but room will not permit I shall only just mention, that these micrometers may be easily applied to the reflecting telescope, and observations made with the same ease and exactness.

From (Martin's) the General Magazine, Sept.r 1764. p. 440.

Effects of the precession of the Equinoxes.

V. p. 9. where 2 stars are calculated to shew this.

By means of the precession of the Equinoctial points ~~the~~ in Antecedentia (or from East to West, contrary to the order of the signs) 50" each year, the fixed Stars appear to move as much in Consequentia (or from West to East, in the order of the signs) increasing their longitudes 50" every year whilst their Latitudes always remain the same. Hereby they likewise continually increase their Right Ascension, and ~~[illegible]~~ declination; For

Stars having North declination & their Right Ascension between the Solsticial Colure of Capricorn & Cancer; Also, those having South declination & their Right Ascension between the Solsticial Colure of Cancer and Capricorn — —	Increase their Declination.
But, Stars having S. Decl. & their R. A. between the Solsticial Colure of Capricorn and Cancer; Also, those having N. Decl. & their R. A. between the Solsticial Colure of Cancer and Capricorn — —	Decrease their Declination

It is moreover observable that a Star of a small ~~Latitude~~ Declination will in ~~time~~ time be overtaken in Right Ascension by one of a greater ~~Latitude~~ Declination; because the Angle formed by the meridian passing thro' the Star and the Circle of Latitude, increases in proportion to the Declin.^{n} Therefore if any two known^n stars should be fixed upon for discovering a true Meridian line, which are now upon different meridians, there will be a time when they will be upon the same meridian and to discover this I have proposed this

Question. Required a general Theorem to find ~~when~~ in what year to come will any two given Stars ~~shall~~ be upon ~~the~~ one and the same or opposite meridian?

Solut. In Fig.s 23, 24, 25, 26, **N** and **A** represents the North pole Star and Alioth (in the great bear's Tail) in several (tho' not all the) positions that may happen, and Fig. 26 their position in the year 1760 when the R. A. of N. increases swifter than that of A, and the declination of **N** increases, but that of A decreases; **n** and **a** represent these two stars ~~at the~~ required time when they are both under the same or opposite Meridians. Now there is given $PE = 23°.29'$ the distance of the Pole of the Ecliptic from the pole of the World: ~~NE~~ $nE = NE = 23°.55'.49''$, $aE = AE = 35°.39'.44''$ the Co-Lat. ~~and~~ the $\angle NEP = 4°.46'.59''$ ~~and~~ the Longitude of N from ♋ in 1760 by Dr Halley's Tables & $\angle AEP = 24°.30'.15''$, the Longitude of A from ♎ by D°. Also ~~and~~ $\angle AEN = 19°.43'.16'' = aEn$ because the Longitudes of both Stars increase by the same quantity in the same time $\therefore = AEP \backsim NEP = 19°.43'.16''$.

The whole of this Prob. is abundantly better solved in p. 123.

Now, in the Spherical Triangles PEn, PEa, let $a, b; c, d$, be the Sines, $\alpha, \beta; \gamma, \delta$ the Cosines of $\frac{PE+nE}{2}$, $\frac{PE \backsim nE}{2}$; $\frac{PE+aE}{2}$, $\frac{PE \backsim aE}{2}$ $t = $ Cotang. $\frac{PEn \backsim PEa}{2} = \frac{1}{2} aEn$, and $x = $ Cotang. of $\frac{1}{2} PEn$;

Then by a well known Theorem in Spherics (at p. 34. of Sherwin's Tables, or what I have wrote from thence at p. 182. of Emers. Trig.)

$\frac{bx}{a} = $ Tang. $\frac{nPE \backsim PnE}{2}$, and $\frac{\beta x}{\alpha} = $ Tang. $\frac{nPE + PnE}{2}$; $\therefore$

By Book I. Prop. VIII. p. 21. Cor. 1. of Emerson's Trig. $\overline{1-\frac{b\beta x^2}{a\alpha}} \div \overline{\frac{bx}{a}+\frac{\beta x}{\alpha}}$ = Cotang. $\angle nPE$.

Much better done on the next page.

Again, by the said Cor. $\frac{tx-1}{x+t} = $ Cotang. $\frac{1}{2} \angle PEa$; ~~and therefore by the said Theorem~~ Whence as before $\frac{dxt-d}{cx+tc} = $ Tang. $\frac{aPE \backsim PaE}{2}$, $\frac{\delta tx-\delta}{\gamma x+\gamma t} = $ Tang. $\frac{aPE+PaE}{2}$, & $\overline{1-\frac{dtx-d}{cx+tc}\times\frac{\delta tx-\delta}{\gamma x+\gamma t}} \div \overline{\frac{dtx-d}{cx+tc}+\frac{\delta tx-\delta}{\gamma x+\gamma t}} =$ Cotang $aPE = nPE$, per Ques. & $\therefore$ is $= \overline{1-\frac{b\beta x^2}{a\alpha}} \div \overline{\frac{bx}{a}+\frac{\beta x}{\alpha}}$; this equation, by proper reductions, gives

$$\frac{\overline{x^2+2tx+t^2}\times c\gamma - d\delta\times\overline{t^2x^2-2tx+1}}{\overline{tx^2-x+t^2x-t}\times\gamma d + c\delta\times\overline{tx^2-x+t^2x-t}} = \frac{a\alpha-b\beta x^2}{\alpha bx+a\beta x} = \text{Cot.}\angle aPE = nPE.$$

The 1st side of this Equation is abbreviated to $\frac{c\gamma\times\overline{x+t}^2}{d\delta\times\overline{tx-1}^2}-1$.

Thus, put $tx-1=y$, and $x+t=z$: Then, $dtx-d=dy$, $\delta tx-\delta = \delta y$, $cx+tc=cz$, and $\gamma x+\gamma t=\gamma z$; $\therefore \frac{c\gamma z^2-d\delta y^2}{\delta dy^2} = \frac{c\gamma z^2}{\delta dy^2}-1$, which by restitution is $\frac{c\gamma\times\overline{x+t}^2}{d\delta\times\overline{tx-1}^2}$, as above.

Again, by the said Cor. $\frac{tx-1}{x+t} = \frac{y}{z}$ (by putting $y = tx-1$, and $z = x+t$) = Cotang. of $\frac{1}{2} \angle$PEa; Whence, as before, $\frac{dy}{cz}$ = Tang. of $\frac{aPE \backsim PaE}{2}$, $\frac{\delta y}{2z}$ = Tang. of $\frac{aPE + PaE}{2}$, and $1 - \frac{dy}{cz} \times \frac{\delta y}{2z} \div \frac{dy}{cz} + \frac{\delta y}{2z} = \frac{mz^2}{y^2}$ (putting $m = \frac{c2}{d\delta}$) = Cotang. of aPE = nPE per Quest. and $\therefore = \frac{a\alpha - b\beta x^2}{\alpha b x + a\beta x}$. Hence by Reduction, & putting $n = m\alpha b + ma\beta$, $nxz^2 = a\alpha y^2 - b\beta x y^2$; by restitution and dividing by $b\beta t^2$, I get $x^4 + \frac{n}{b\beta t^2} - \frac{2}{t} \times x^3$
$\frac{2nt + b\beta - a\alpha t^2}{b\beta t^2} x^2 + \frac{nt^2 + 2a\alpha t}{b\beta t^2} x = a\alpha$. Solved $x =$
= Tang. ° ' " ; whence, seeing N is in the first quadrant from A, As 50": 1 Year :: 360° − 2x : Years, to which add 1760. gives ~~the year~~ ~~in which~~ for the year required.

Scholium I.

If in these figures, E be the North pole, P the Zenith of a given place A and N two known stars, at any given or supposed time; then the Angle NEn = AEa, will be the time from that given or supposed in which these stars shall both appear upon the same vertical circle Pna; the time found will be before or after that given or supposed according as

V. the proportions on p. A7 & A9. But the most natural & easy time for that given or supposed is when one of the stars is upon the meridian, wherefore, in fig.s A1. & A2. let P be the North pole, Z the zenith, BbF, MaO the path of two known stars, and Zba an azimuth ~~circle~~ or vertical circle. ~~Suppose the upper star at B~~ The upper star is supposed upon the meridian at B in fig. A1. when the other is at A; and the lower upon the meridian at A, in fig. A2. when the other is at B. Wherefore to find the declination of the plane passing through these two stars when they both come upon the same vertical circle Za, at b and a; bP, aP are the co-declinations, ~~aPb~~ aPb = APB, the difference of their Right Ascen.ˢ from b let fall the perpendicular bC upon aP; then (as in the solution to the above quest. at p. 124.) Rad.: Tang. bP :: cos. bPa : tang. PC; and Pa − PC = Ca; then again, S. Ca : S. PC :: tang bPa : tang. ZaP; and S ZP (= co-lat. of the place) : S. ZaP :: S.Pa : S. aZP, the declination of the plane from the North; whether East or Westward is determined by the Rule on p. 53. — Should the time of this observation be required; proceed as in the solution just referred to, for here are the same data and quesita, as in that question. — Fig. A1 is when both are upon a South Azimuth Za, and A2. when upon a North Azimuth Za; but should one have a North ~~aspect~~ and the other a South ~~one~~ aspect, & both at the same time upon the same vertical plane; as the one at a and the other at β, then add 180° to the lesser, ~~or~~ subtract it from the greater Rt. Ascens. their places will be reduced to the same aspect, ~~as~~ upon the same Azimuth circle, as at α & β and the difference between this sum or difference, and the Right Ascens. of the other star is the angle αPβ, with which, & their co-decl. αP, βP proceed as before.

By two of these observ.ˢ of 4 known ✱s, the latitude of the place; time; &c. may be found.

Scholium II

In the last Scholium there is no necessity to have the R. A. and declin.ⁿ of the stars, provided their Longitudes & Latitudes are known; for if P be the pole of the ecliptic, then aP, αP, bP, βP; & bPa, βPα will be the co-latitudes, and difference of their Longitudes instead of the co-declin.ˢ & difference of R.A. also ZP will then be equal to the colatitude of the place ~~plus~~ 23° 29'.

On the Transit of ♀ over ☉ and the Sun's Parallax.

Remarks on the Times of the internal and external Contacts of the Egress of Venus from the Sun, as observed by M. Pingrè at Rodrigues, in 1761 Addressed to Astronomers; but especially to the French Astronomers. By PHILALETHES LONDONENSIS.

The times of the internal and external contacts of Venus with the sun's limb, sent to the Royal Academy of Sciences at Paris, and to the Royal Society at London, are, $0^h..34^m..47^s$ and $0^h..53^m..18^s$. If we compare these times with the times of the same contacts at Tobolsk, the sun's parallax comes out by the first = 7,36.^{s} and, by the last, = 8,36^s and, if we compare the same times by Pingrè, with those made at the Cape of Good Hope, the results will be, = 11,24^s and 8,20.^{s}

If we compare the observations of the internal and external contacts at the Cape and Tobolsk, the results will be, = 8,64^s and 8,32.^{s}

This, then plainly shews, that there must be a mistake in the time of the internal contact at Rodrigues; and we find that M. Pingrè, after his arrival at Paris, has altered his times both of the internal and external contact, giving this for his reason, in a letter to the Royal Society, "that his clock being slow, $1^m..2^s$. he had, in the numbers before sent to Europe, subtracted the $1^m..2^s$ instead of adding them." If, therefore, we allow this correction to be just, and compare these new times with the times at Tobolsk, the results of the sun's parallax, from these new numbers, will be, = 9,98.^{s} and 11,23.^{s} and by comparing them with those at the Cape, = 5,66^s and 2,90.^{s} This, therefore, again shews, that these new numbers are not the true ones, and that M. Pingrè, being, perhaps, aware of this, has added $2^m..2^s$ to the time of the internal contact, as sent to Europe; and only $1^s..2^s$ to the time of the external contact, tho' in every other observation he has added $2^m..2^s$. and the reason is plain, for if he had added the $2^m..2^s$. also to his external contact, he had made the duration of the egress longer, by one whole minute, than it was observed any where else.

Upon the whole, may we not conclude, that, since the time of the external contact, as sent to Europe, agrees in giving the same parallax of the sun, with that given by all other observations of the same contact; and since the time of the internal contact, as given by M. Pingrè, since his arrival at Paris, disagrees with the results of other places, in the quantity of the sun's parallax, there must needs have been an error of one minute, in the time of his nearest contact, as sent to Europe; and that this contact should have been set down at $0^h..35^m..47^s$? This being admitted, if we compare the times of internal and external contacts at Rodrigues, with the times of the of the same contacts observed at Tobolsk, the parallax of the sun comes out = 8,62^s and 8,36.^{s} and, if compared with the times at the Cape, the results are, = 8,54^s and 8,20.^{s} as will more fully appear from the following comparisons, in which the times of the internal and external contacts at the Cape, as they were sent to Europe, are compared with the times of the same contacts observed at eight different places in Europe, and the result of each comparison given; and the times at at Rodrigues as sent by M. Pingrè, are also compared with the same places

	Int. Cont. s.	Ext. Cont.
Rodrigues & Greenwich	= 6,26	8,75
Paris	= 6,37	8,18
Bologna	= 6,09	9,06
Upsal	= 6,91	8,47
Stokholm	= 6,55	8,57
Cajaneburg	= 7,15	8,8
Tornea	= 6,93	8,44
Tobolsk	7,36	8,36
	8) 53,62 (6,70)	68,25 (8,53.

	Int. Cont. s.	Ext. Cont. s.
Cape & Greenwich	= 8,40	8,48
Paris	= 8,56	8,19
Bologna	= 8,54	8,59
Upsal	= 8,57	8,36
Stokholm	= 8,33	8,41
Cajaneburg	= 8,56	8,33
Tornea	= 8,41	8,35
Tobolsk	= 8,64	8,32.
	8) 68,01 (8,50)	67,03 (8,38.

So that the parallax of the Sun, by a mean of eight comparisons of the internal ~~and external~~ contact at the Cape, is $= 8,50^s$ and of the external contact $= 8,38^s$. But by the internal contact at Rodrigues it is $= 6,70$. and by the external it is, $\doteq 8,53^s$. this last determination agreeing ~~with~~ very nearly with that by both the contacts at the Cape; a strong proof that there must be an error of one minute in the time of the internal contact at Rodrigues. Let us therefore suppose that the internal contact happened there at $0^h. 35^m. 47^s$ and then by - - -

	s
Rodrigues & Greenwich	8,33 Int. Cont.
Paris	8,58
Bologna	8,54
Upsal	8,58
Stokholm	8,07
Cajaneburgh	8,57
Tornea	8,33
Tobolsk	8,62
	8) 67,62 (8,45^s.

The very near agreement of the determination of the Sun's paralax, both by the internal and external contacts at the Cape of Good Hope, is a strong proof of the goodness of those two observation; and this is confirm. by the external contact at Rodrigues, giving the very same determination. It manifestly, therefore, follow, that there must be an error of one minute of time, in setting down the internal contact at Rodrigues: And (as has been remarked in Mr Short's second paper on the Sun's parallax, printed in the Philosophical Transactions) the duration of the egress at Rodrigues likewise requires such a correction of the time of internal contact. What reasons M. Pingré had to make the alterations of his times in his memoir on this subject, he himself best can tell; for my part, I can only guess at them.

Gentleman's Magazine for June 1766 p. 277 & 278.

By altering the said Observation of Mr Pingre of the internal contact, and comparing a great number of observations and computations, Mr Short, in the last Vol. of the Philos. Trans. tells us they all coincide so near, that there cannot be an error in the Sun's parallax $8,56^s$ of one tenth of a second, and probably the error does not exceed one five hundredth of the whole quantity. But the Revd. Mr Hornsby, M.A. professor of Astronomy at Oxford, and F.R.S. in the same Volumn of the Transactions, concludes thus, That taking the mean of a great number of observations and computations, the Sun's parallax is $9,732^s$ and in this quantity we must either acquiesce, or remain as ignorant of the true quantity of it as we were before. The French astronomers still differ, they make the Sun's parallax from some observations, $10,4^s$. from others, $9,55^s$ and even $7,5^s$. Hence this

Author in the said Mag. for July 1766 page 316 goes on and asserts the difference of the results in the foregoing letter arise from the method of computation & that there is not one true method yet made public.

Again in the last mentioned Mag. p. 322. Philalethes Oxoniencis, after assigning the cause of the mistake in the Observations of M. Pingré, says. — "M. Pingré, in his Memoir printed in the Royal Academy's Vol. for the Year 1761, tells us, that the principal objection of his mission to the island of Rodrigues, was the determination of the Sun's parallax; and therefore he used his utmost care & attention in measuring the apparent least distance of the centers of the sun and Venus, and never neglected any opportunity of doing the same, as often as the wind & rain would permit. This apparent least distance of the centers, as measured by M. Pingré, is set down = 561, 69 sec. being the mean of a great number of measurements, and consequently very near the truth. — M. Mallet, the Royal Observer at Upsal in Sweden, in a letter lately read at the R. Society, says, that he measure the apparent least distance of the centers at Upsal repeatedly, and found it, on a mean, 590, 6 s. These two determinations of the apparent least distance of the centers, at these two places, must be allowed to be true, or at least very near the truth, when we consider the abilities of the two observers. The difference between these two numbers, = 28, 91 s. is a base from which we can deduce the parallax of the sun; which accordingly we find = 8, 73 s. agreeing very nearly with what was determined by the internal and external contacts in the paper of Phil. Lond. & is a further proof that there must have been an error of one minute of time in setting down the time of the internal contact at Rodrigues. This last determination of the Sun's parallax, by the apparent least distance of the centers, does not depend on the difference of longitude of the two places being accurately known, whereas that by the contacts does; and the very near agreement of these two determinations strongly confirm each other. This determination by actual measurement at Upsal, of the apparent least distance of the centers, is also a proof that there is a mistake in M. Pingré's method of determining the apparent least distances of the ~~cent~~ centers by the total duration observed at any place; for by that method M. Pingre makes the apparent least distance of the centers at Upsal = 595, 62 s.; and is a confirmation of the truth of the method given by Mr. Short, in his second paper on the sun's parallax, printed in the Phil. Trans. for 1763: For by his method, and making use of his elements, we find, that, on the Supposition of the Sun's parallax being = 10 s, 8, 5 s. and 7 s. the apparent least distances of the centers at Upsal must be (from the total duration observed, = 5h 20m 26s) = 589″822; 589″892, and 589″938: And if we compare these three apparent least distances, computed for Upsal, with the apparent least distance measured at Rodrigues, the Sun's parallax on these three Suppositions is 8, 50 s. 8, 52 s. and 8, 53 s. This determination of the Sun's parallax, by the least distance of the centers deduced from the total duration observed, is more certain than that found by actual measurement in these northern latitudes, as has been observed in Mr. Short's 2d paper. If we extend this method of his to a place in Southern

latitude, such as Rodrigues, the results of the apparent least distance of the centers, by computation from the total duration observed, will be very different on these three different suppositions; and hence arises a beautiful problem, To determine the Parallax of the Sun, in a Transit of Venus, from three observations made at one place only." Gents Mag. July 1766. p. 322 and 323.

Cambridge, Sept. 20th 1765.

A Board of Longitude to examine Harrison's Watch.

We hear from London, that on ~~Tuesday last~~ Thursday last Week was held a Board of Longitude, to inspect and receive the Explanation of Mr. Harrison's Time-keeper, when the Son of Mr. Harrison being called in, he was acquainted, that the Commissioners were satisfied that his Father had made a full Discovery of his Machine to the Gentlemen appointed by them for that purpose; and that it was by them resolved to grant him their Certificate, upon his delivering up to them, or their order, his Watch and three other Time-keepers before made, as the Property, and for the use of the Public; a formal Instrument of which is now drawing up by their Lawyer. The Names of the Commissioners present were,

Those Commissioners of the Board of Longitude were present.

Lord Egmont — Lord Dartmouth — Sir George Pocock — Sir William Rowley — Admiral Osborne — Adm. Knowles — Rev.d Dr Long, Lowndes Professor of Astronomy, and Master of Pembroke-Hall in this University — Rev.d Dr Shepherd, Plumian Professor of Astronomy and Experimental Philosophy, and Fellow of Christs College — Rev. Dr Mr Maskelyne, Astronomer Royal, and Fellow of Trinity College — Mr Waring, Lucasian Professor of Mathematics, and Fellow of Magdalen College — Rev. Mr Betts, Savilian Professor of Geometry, at Oxford — Mr Stephens, Secretary to the Admiralty — Mr Cockburn, Comptroller of the Navy — Mr Lowndes — and Mr Mellish.

Inspectors of the Time-piece.

Inspectors of the Time-keeper appointed by the Commissioners were

Rev.d Mr Ludlam, Fellow of St John's College — Mr Bird — Mr Kendal — Mr Mudge — and Mr Matthews.

The Rev. Mr Michell, late Woodwardian Professor, and Fellow of Queen's College, could not attend, but sent his report in writing.

His reward £10,000.

By Virtue of the above-mentioned Certificate, when signed, Mr Harrison will received the further sum of Seven thousand Five hundred Pounds, compleating the first Ten thousand Pounds for his Discovery of the Longitude. Cambridge Journal. for Sept. 21st 1765.

The follow is an exact Copy of the Report delivered into the Hon. Board of Longitude, by one of the Gentlemen to whom Mr Harrison was referred to make a Discovery of the Principles of his Time-Piece.

A Short view of the Improvements made or attempted in Mr Harrison's Watch.

Harrison's Defects in common Watches.

THE Defects in common Watches, which Mr Harrison proposes to remedy, are chiefly these:

1. That the Main Spring acts not constantly with the same force upon the Wheels, and through them upon the Ballance.

2. That the Balance, either urged with an unequal Force, or meeting with a different resistance, from the air, or the oil, or the friction, viberates through a greater or less arch.

3. That these unequal Vibrations are not performed in equal Times.

4. That the Force of the Balance Spring is altered by a change of Heat.

Remedies proposed and correct in his Watch.

Main Spring made to act equally.

1. To remedy the first defect, Mr Harrison has contrived, that his watch shall be moved by a very tender spring, which never unrolls itself more than one-eighth Part of a Turn, and acts upon the Ballance through one wheel only. But such a Spring cannot keep the watch in Motion a long time. He has therefore joined another, whose office is to wind up the first spring eight times in every minute, & which is itself wound up but once in a day.

Viberations of the Balance made more Uniform

2. To remedy the second defect, Mr Harrison uses a much stronger Ballance Spring, than in a common watch. For if the force of this spring upon the Ballance remains the same, whilst the Force of the other varies, the errors arising from that variation will be the less, as the fixed Force is the greater. But a stronger Spring will require either a heavier or a larger Balance. A heavier Balance would have a greater friction. Mr Harrison therefore increases the Diameter of it. In a common watch it is under an inch, in this of Mr Harrison's two inches and two tenths.

Times of these Vibration made equal.

3. Had these remedies been perfect, it would have been unnecessary to consider the defects of the third sort. But the methods already described, only lessening the errors, not removing them, Mr Harrison uses two ways to make the times of the vibration equal, tho' the arches may be unequal. One is to place a pin, so that the balance Spring pressing against it, has its force increased; but increased less when the vibrations are larger; the other to give the palates such a shape, that the wheels pressing them with

A Brass & Steel bar rivetted together, & prevent the irregularity of the balance Spring arising from Heat.

less advantage, when the vibrations are larger.

4. To remedy the last defect, Mr Harrison uses a Bar compounded of two thin plates of Brass and Steel, about two inches in length, rivetted in in several places together, fastened at one end, and having two pins at the other, between which the Ballance Spring passes. If this bar be streight in temperate weather (brass changing its length by heat more than steel) the brass side becomes convex when it is heated; and the steel side when it is cold: And thus the pins lay hold of a different part of the spring in different degrees of heat, and lengthen or shorten it, as the Regulator does in a common Watch.

Remarks on these remedies & how far they may be imitated.

The two first of these Improvements, any good Workman, who should be permitted to view and take to pieces Mr Harrisons Watch, and be acquainted with the tools he uses, and the directions he has given, could without doubt, exactly imitate. He could also make the palates of the shape proposed; but for the other improvements, Mr Harison has given no rules. He says, that he adjusted those parts by repeated trials, and that he knows no other method. This seems to require patience and perseverance; but with these qualifications other workmen need not despair of success equal to Mr Harrison's. There is no reason to suspect that Mr Harrison has concealed from us any part of his art.

If our opinion of the excellence and usefulness of this Machine be asked, I must fairly own, that nothing but experience can determine the value of it with certainty; however, I think it my duty to declare to the board the best judgment I can form.

Strictures thereon.

The first of Mr Harrison's alterations is, I believe, an improvement, but not very considerable. Probably if the other defects in common watches could be removed, the changes in the ~~motion~~ Force of the main spring would not occasion such errors, as would make them useless at Sea.

The next alteration seems to be of great importance. I suppose that it contributes more to the exactness of the watch, than all the other changes put together. But it is attended with some ~~ill convenience~~ inconvenience The watch is liable to be disordered, and even stopped by almost any sudden motion, and, when stopped, does not move again of itself. But as it has gone two voyages without any such accident, it may seem, that this danger at Sea is not so considerable.

The Principle on which Mr. Harrison forms the alterations of the third sort is, that the longer vibrations of a balance moved by the same spring, are performed in less time. this is contrary to the received opinion among Philosophers and Workmen. But if Mr. Harrison is right, yet whether the method he has proposed will correct the errors, or not, is to me quite uncertain.

The last alteration before-mentioned is ingenious and useful; but that it can be made to answer exactly to the different degrees of heat, seems impossible.

From the Cambridge Journal for Sept. 21st. 1765. WILLIAM LUDLAM.

Advantages arising from a new position of the fusee in ~~a~~ common watches. By M. LeROY. Gent's Mag. for Augt. 1766. p. 369.

THE size and number of Teeth of the wheels, and of the leaves of the pinions, are not the sole objects which require our attention in such machines as consist of toothed wheels, and especially in clockwork; besides which, there is another very simple principle, which it is surprizing it should not have hitherto been considered, though perhaps as necessary as any other, to the perfection of those machines.

This principle is the position of wheels and pinions upon their arbor, at an equal distance as far as is possible, the utility whereof may be thus explained.

Pivots gull their holes

V. Philos. Trans. No. 112. Vol. I. p. 465. of Lowthorp's Abridgment.

The several wheels which compose a machine, are designed to transmit from one to another, the force which the first of them received from the ~~other~~ moving power. The pivots receive a ~~considerable~~ constant pressure towards one certain side of the hole, in which they turn round; from whence necessarily ensues a tendency in them to wear, enlarge, and gully the hole on that side which they rub against, and that when they have once begun to wear it, the cavity is very quickly enlarged, because the surface of the hole becoming irregular, occasions a greater resistance, and a greater friction.

Every wheel of a watch is fixed upon an arbor, which terminates in two pivots, and these turn in holes drilled in the plates of the watch. Each arbor is charged ~~with~~ both with a wheel and pinion; and it is the pinion which receives the action of the immediate preceding wheel, and transmits it to the wheel fixed on its own arbor.

A Problem.

Now at what place of the length of the arbor ought the wheel and pinion to be fixed? This has every been thought quite indifferent, however it is certain it cannot be so; and as it commonly falls out, that when we act at hazard, we make a bad choise, or at least, not the best; just so has it happened on this occasion, and the usual arrangement or caliber, in this respect, carries with it several inconveniences, which could not escape the penetration & enquiries of M. le Roy.

Wheel & pinion fixed nearest the middle of their arbor are best.

He remarks first, that a watch wheel placed near the middle of its arbor, is in the most advantageous position, especially if its pinion be nearly in the same position; because, then the effort it receives, is distributed equally between the two pivots; the pivot holes in the two plates, will wear equally, and on the same side, and their enlargement will always let the wheel continue parallel to the plates: The consequence will be, that the positions of the planes of the wheels, suffering no alteration by such wearing, with respect to one another, they drive one another on without any alteration, as to the pitching, or the friction.

A contrary case.

But the case will be otherwise, when the wheel or the pinion are near one of the extremities of the arbor, as the friction arising from the action of the wheel, is no longer equal on both the pivots; that which is nearest the pinion, receives almost the whole effort of the preceding wheel, whilst the other is effected with it in a very slight degree only. It must thence follow, that the hole of such pivot must wear much more, and that in a shorter time, than the other; whence must be produced a disorder, as to the justness of the watch: And yet this is not the worst consequence to be apprehended; one of the holes cannot wear, or be enlarged more than the other, without altering the position of the arbor, and consequently that of the parallelism of the plane of the wheels; whence it follows, that the pitching must be absolutely altered, and the watch lose much of its justness.

And the disorder thence arising

Position of the fusee hinders a correction

This is the great defect of common Watches, the pinion of the small middle wheel, or the third wheel M (in Fig. 24.) and that of the contrat wheel Y are so near one of their pivots, that it is very frequently necessary to stop or bush up their holes & drill them anew in a year or two. M. le Roy set himself about remedying this mischief for several years; but the situation of the fusee was an obstacle to his placing the little middle wheel as it ought to be. The fusee is a kind of truncate cone, much wider at the base than the top, and is raised the higher by the fusee wheel at bottom; in so much, that at about half the distance between the two plates, it is impossible for the small middle wheel to have its requisite diameter, without placing it at the top of its arbor, and its pinion at the bottom of the same.

Yet remedied by inverting the fusee.

To remedy this inconvenience, M. le Roy at last thought of inverting the fusee, so that the wide base should be at top, and little end at bottom, near the great wheel; for the main thing to be done was to lower the little middle wheel in the frame, and the inversion of the fusee being once put in practice, the obstacle no longer subsisted. The little middle wheel being thus se raised to a sufficient height, might act upon the pinion of the contrat wheel, near the middle of its arbor; and this upon trial, perfectly answered the purpose of the artist.

New positions of the wheels.

In fig. 28. the fusee is shewn inverted at F, the great wheel at G, the little middle wheel at M, a little cap at

B.

B(*) the cantrat wheel at R, and the cock at C, which is thus designed to shew, that this is to be called the <u>upper side</u>, <u>or the top of the frame</u>; the other parts are suppressed, the better to represent only the necessary ones. Fig. 27. represents the same parts of an ordinary watch, that by comparing the two constructions, the new may ~~the~~ be the easier judged of; F is the fusee in the common position, the little middle wheel being at M at the top of the frame.

Advantages thereof.

This new position of the fusee has not only the beforementioned advantages; but it has also one more above the <u>English</u> watches, or such as wind up at bottom, which renders the caliber as perfect as possible. For by this inversion of the fusee, its base being, in those watches, on the same side, as the square of the great pivot; the diameters of the pivots, are proportioned to the friction they suffer; whereas in <u>English</u> watches, the greates ~~p~~ pivot is on the side where the chain draws nearest the centre; that is precisely on the wrong side.

A Problem, for the use of determining the Times, &c. proper for discovering a meridian by the 3.d way on pag. 53.

How long, and what time of the year, can <u>Alioth</u> in the great Bear's Tail, whose Right Ascension is 190°. 56'. 10" (given on p. 19.) be observed upon the Meridian, ~~both~~ above and below the pole, in the Latitude of 52° N.?

Solution. In figs. 35, 36, 37, & 38. (perhaps one might be drawn to serve for all four; for the red lines in the one represent the black ones in the other, and thereby two is sufficient, yet I shall here use the four & only the black lines) ♈Q = ♎Q = 10°. 56'. 10" the <u>Medium Cœli</u>; ∠C♈Q = C♎Q = 23°. 29' the greatest declination of the ecliptic, and CQ♈, or CQ♎ right: then, As Rad. : Tang. C♈Q = C♎Q :: S. ♈Q = ♎Q : tang. CQ = 4°. 42'. 43" the declination of the culminating point C, north when <u>Alioth</u> is below the pole, as in figs. 35 & 36. but south when above it, as figs. 37 & 38. Again, As S. C♈Q = C♎Q : S. CQ :: Rad. : S. C♈ = C♎ = 11°. 53'. 48" the culminating point. And (since all the terms have been used) As S. CQ : S. C♈Q = C♎Q :: S. ♈Q = ♎Q : S. ♈CQ = ♎CQ, rather than As Rad. : Cot. ♈Q = ♎Q :: tang. CQ : Cot. ♈CQ, or (by making ♈CQ middle part) Rad. : Cos ♈Q :: S. C♈Q : Cos. ♈CQ = 66°. 53'. 53".
Since Alioth is of the 2.d Magnitude it becomes visible when the Sun is depressed 13° below the horizon, and therefore, AB being the parallel of that depression, OA = 13°, & OQ = 38° the Co Lat. ~~whence CA in fig. 35. = CQ + QO + AO = 55°. 42'. 43". in the triangle CeA, right ∠d at A, As Rad : Cot. CA :: Cos. eCA : Cot. eC = 75°. 1'. 20"; and eC − ♈C = ♈e = 63. 4. 32.~~

Since the time of <u>Alioth's</u> ~~coming~~ arriving ~~to~~ at any fixed point anticipates that of the Sun, it is evident <u>Alioth</u> will first appear ~~upon the meridian~~ and disappear upon the meridian, when the Sun is depressed 13° below the horizon on the East and West side of the globe or before his rising & after his setting, respectively. Wherefore for the Star's first appearance below the ~~horizon~~ Pole, in fig. 36. AC = OQ − OA + QC = 29°. 42'. 43"

(*) M. <u>le Roy</u> makes the lower pivots, not to turn, ~~in~~ in the plate of the frame, but in another little plate, or cap placed on the outside the frame-plate; by which contrivance, he renders the effort of the pivots nearly equal, and keeps the oil from ~~quitt~~ quitting the pivots, as it is ~~too~~ too apt to do in the common struction.

in the Δ AEC, As Rad. : Cot. AC :: Cos. ECA : Cot. EC = $55^\circ.29'.20''\frac{1}{2}$ from which take ♎C, leaves ♎E = $43^\circ.35'.32''\frac{1}{2}$, or ♌ $26^\circ.24'.27''\frac{1}{2}$ corresponding to August 19^th^.

2. For its disappearance under the pole. In fig. 35. CQ + QO + OA = CA = $55^\circ.42'.43''$; and in the triangle CeA, r.^t^ ∠.^ed^ at A, As Rad. is Cot. CA :: Cos. eCA : Cot. eC = $75^\circ.1'.20''$; eC − ♈C = $63^\circ.7'.32''$ or ♑ $26^\circ.52'.28''$; corresponding to the 16^th^ of January.

3. For its first appearance above the pole. In fig. 38 AH + HB − DÆ = DB = $46^\circ.17'.17''$. and As Rad. Cot. DB : Cos. BDe : Cot. De = $69^\circ.26'.18''$, to which add D♎ (♈C) gives ♎e = $81^\circ.20'.6''$ answering to ♐ $21^\circ.20'.6''$ and December the 13^th^.

4^th^. For its disappearance above the pole. In fig. 37. in the supplemental triangle BED, HÆ − HB − DÆ = BD = $20^\circ.17'.17''$, As Rad. : Cot. BD :: Cos. BDE (♎CQ) : Cot. DE = $43^\circ.17'.3''$ to which add ♈D (♎C) gives ♈E = $55^\circ.11'.25''$ corresponding to ♉ 25.11.25 and May the 16^th^. Q. E. I.

N.B. only the black lines in each figure are used.

But all these proportions from the last line on the last page may be more concisely & methodically expressed, when E is put also in the place of e in figs 35 & 38. thus

$$\text{Rad.} : \text{Cot. } AC = OQ \begin{cases} +QC-OA, \text{ in fig. } 36. \\ +QC+OA, \text{ in fig. } 35. \\ -QC-OA, \text{ in fig. } 38. \\ +OA-CQ, \text{ in fig. } 37 \end{cases} :: \text{Cot. } ECA : \text{Cot. } EC = \begin{cases} 55^\circ.29'.20''\frac{1}{2} \\ 75.1.20 \\ 110.33.12 \\ 124.48.35 \end{cases}$$

From which take ♎C / ♈C gives: ♎E = 43.35.32½; ♈E = 63.7.32; 98.39.54; ♎E = 112.54.47 — corresponding to — ♌ $26^\circ.24'.27''\frac{1}{2}$ and August 19. ♑ 26.52.28 and January 16. ♐ 21.20.6 and December 13. ♉ 25.11.25 and May --- 16.

Whence Alioth appears upon the meridian ~~above~~ under the pole from ~~December from~~ Aug.^st^ 19. to Jan.^y^ 16. and above the pole from December 13. to May 16. Q. E. I.

Quest. on p. 112 better solved from line the 23

(*) See the ~~next page~~ following page

From a and n let fall the perpendiculars aC, ne, upon EP produced: put m, t, for the Tang. of En, Ea; a, b, x the Sines, and c, d, y the cosines of PE, nEa, PEn. then Rad. : y :: m : my = tang. Ee, by Prop. VI. B. I. of Emer. Trig. $\frac{myc-a}{\sqrt{1-m^2y^2}}$ = s. Pe; $\frac{my}{\sqrt{1-m^2y^2}}$ = s. Ee; whence by a reciprocation of Cor. 3. to Prop. 28 B. III. $\frac{myc-a}{\sqrt{1-m^2y^2}} : \frac{my}{\sqrt{1-m^2y^2}} : \frac{x}{y}$ (tang. PEn) : $\frac{mx}{myc-a}$ = tang. nPE. By Prop. V. B. I. $dx+by$ = s. and, by Cor. 1. to ditto, $dy-bx$ = cos. PEa. then as before, Rad. : $dy-bx :: t : \overline{dy-bx}\times t$ = tang. CE: $\frac{\overline{dy-bx}\times tc-a}{\sqrt{1+\overline{dy-bx\times t}^2}}$ = s. PC;

$\frac{\overline{dy-bx}\times t}{\sqrt{1+\overline{dy-bx\times t}^2}}$ = s. EC; and $\frac{\overline{dy-bx}\times tc-a}{\sqrt{1+\overline{dy-bx\times t}^2}} : \frac{\overline{dy-bx}\times t}{\sqrt{1+\overline{dy-bx\times t}^2}} ::$

$\frac{dx+by}{dy-bx}$ (tang. PEa) : $\frac{\overline{dx+by}\times t}{\overline{dy-bx}\times tc-a}$ = tang. aPE = nPE,

and ∴ = $\frac{mx}{myc-a}$: Whence, by reduction, $y^2+x^2-\frac{a}{mc}y=$

~~$\frac{ad}{bmc}x - \frac{a}{btc}x$; wherein $y^2+x^2=1$ (Rad.); $\frac{a}{c}=$ tang. PE $=T$; $\frac{b}{d}=$ [illegible] cot. nEa $=\tau$; ∴ ($\frac{T\tau}{m}x+\frac{T}{m}y-\frac{T}{bt}x=1$; or rather $\frac{\tau}{m}x+\frac{1}{m}y-\frac{1}{bt}x=\frac{1}{T}$, or, by dividing by $\frac{T}{m}$, better thus) $y+\overline{\tau-\frac{1}{bt}m}\times x=\frac{1}{T}m$. ∴ $y+\overline{\frac{d}{b}-\frac{m}{bt}}\times x=\frac{cm}{a}$; where $\frac{1}{m}$ is the Cot. nE, $\frac{b}{d}=$ tang. nEa, and $\frac{c}{a}=$ cot. PE; from which it is even easy to approximate the value of x; but, putting $\frac{d}{b}-\frac{m}{bt}=-r$, and $\frac{c}{a}=\tau$; $x=\sqrt{\frac{1}{r^2+1}-\frac{1}{r^2+1}m\tau^2+\overline{\frac{1}{r^2+1}mr\tau}|^2}-\frac{1}{r^2+1}mr\tau=$~~

within the red crotchets amounts to nothing.

To be taken in at the (*) on the foregoing page.

(*) The numbers given on p. 112 are most of them wrong, the true ones are therefore here repeated.

Now there is given PE = 23°. 29′ the distance of the pole of the ecliptic from the pole of the world; NE = nE = 23°. 55′. 49″, AE = aE = 35°. 39′. 44″ the colat.; NEP = 4°. 42′. 49″; AEP = 65°. 33′. 55″ the long. of N and A from ♋ in 1765, by Dr Halley's Tables, which being on different sides of ♋, their will give NEA = 70°. 16′. 44″. It is plain, at the end of the time required, this NEA = nEa, because the longitudes of both stars always increase by the same invariable quantity in the same time.

$\frac{ad}{bcm}x-\frac{a}{bct}x$; wherein $y^2+x^2=1$ (Rad.) thence, by reduction and putting $\frac{d}{b}-\frac{m}{bt}=\pm r$, and $\frac{c}{a}=\tau=$ cot. EP; x is had $=\mp\frac{rm\tau}{r^2+1}+\sqrt{\frac{1-m^2\tau^2}{r^2+1}+\overline{\frac{rm\tau}{r^2+1}}|^2}$; the upper or lower sign taking place according as $\frac{d}{b}$ is greater or less than $\frac{m}{bt}$; Solved $x=$

Or thus

Put a, k, b, p, x for the sines, c, l, d, q, y for the cosines of PE, nE, nEa, aE, PEn. Then by prop. V. B. I. of Em. Trig. $dy-bx=$ $dx+by=$ sine, and by cor. 1. to the same prop. $dy-bx=$ Cos. of PEa: whence, by spherics $\frac{kx}{al-kcy}=$ tang. nPE = aPE, & ∴ $=\frac{pdx+pby}{aq-pcdy+pcbx}$: whence by reduction, $\frac{ald}{bck}x-\frac{aq}{pcb}x=y^2+x^2-\frac{al}{kc}$, wherein $\frac{l}{k}=\frac{1}{m}$, and $\frac{q}{p}=\frac{1}{t}$, as substitude above, which used in the process as before, the value of x comes out exactly the same, as there found.

But best of all thus.

Fig. 39 & 40 are only a repetition of the 26th and 25th because the Northpole star at N is on the contrary side the pole P to that of Alioth at A, and therefore is apparently better. —— From a let fall the perpendicular ac upon nE: Then per Spherics, (in fig. 40. nEP is greater than NEP, because N now having a greater than that of A minus 180°.)

Rad. : tang. aE = 35°. 39′. 44″ – 9,8558664½	S. Cn = 10. 19. 7 60 Ar. 0,7468516
:: cos. nEa = 70°. 16. 44 – 9,5281993	: S. CE = 13. 36. 42 —— 9,3716957
: tang. CE = 13. 36. 42 – 9,3840657½	:: tang. nEa = 70. 16. 44 —— 10,4455502
taken from nE = 23. 55. 49	: tang. anE = 74. 44. 20½ —— 10,5640975.
Remd. Cn = 10. 19. 7	

Upon an let fall the perpendicular ED: Then

Rad. : cos. nE = 23°. 55′. 49″ – 9,9609651	cot. nE = 23°. 55′. 49″, 60 Ar. 9,6471609
:: tang. n = 74. 44. 20½ 10,5640975	: cot. PE = 23. 29 —— 10,3620437
: cot. nED = 16. 37. 12⅓ 10,5250626.	:: cos. nED = 16. 37. 12⅓ —— 9,9814661
	: cos. DEP = 11. 50. 0½ —— 9,9906707
	nED – DEP = 4. 47. 12 = nEP, ~~required~~

the longitude of the North pole star from ♋ toward ♊. at the time required: (but if you work with the ∠naE = 42°. 9. 38¼, instead of anE above, it comes out = 4°. 47′. 6″. ~~but~~ and by proportioning from their Rt. Ascension given on p. 19. it gives 4°. 47′. 23½) · from which subtract PEN = 4. 42. 49, leaves 0°. 4′. 23″, the increase of longitude since it was upon the merid. with Alioth; the supplement of which to 360° is 359°. 55′. 37″ the increase of longitude when it will again be upon the merid. with Alioth, wherefore, 50″ : 1 Year :: 359°. 55′. 37″ : 25914¾ Years, to which add 1765, gives ~~the year~~ the latter end of the Year 27679 for that required. 2. E. I.

A way of making strong Artificial Magnets, without the help of any Magnet, Natural, or Artificial.
Gent.s Magazine Nov. 1766. p. 545.

Against the side, and parallel to the edges of a strong board AA, (fig.) fixed in the plane of the magnetic meridian, and inclined according to the inclination of the dipping needle, (that is, here in England, in a plane declining from the true meridian, westward, about twenty degrees, and with an inclination of about 75 degrees northward) place in the same direction, by the means of pins to rest upon, two iron bars, B, B, each four or five feet long, and about one inch and a quarter square, fitted truly flat and perpendicular to their length at E, E; to each of these flatted ends must be applied, by way of armature, a piece of square plate iron about 1–6th of an inch thick, with chamfered edges rising a little about the surfaces of the bars all round. These are to be kept asunder by a small bit of wood, DD, half an inch thick.

Every thing being thus disposed, take the piece of steel, SCN, designed for the artificial magnet, and stroke it repeatedly up and down, from end to end, over the edges of the plate irons EE, first one side and then the other. It is surprizing to see how soon and how strongly, not only small bars, but large ones, even of a foot long, will be thus impregnated with magnetism; and if iron bars of ten feet each be made use of, the effect will be still more astonishing.

It is generally held, that the steel bars intended for magnets should be made as hard as possible before they are impregnated. This may hold good in some particular sorts of steel; but in most sorts it will be better, after they have been so hardened, to set them down, to blue, by placing them in a proper degree of heat. However, as to the different treatment of particular steel, perhaps more hereafter. It is at p. 127.

Fig. is a draught of an Engine to turn Screws. Gent's Magaz. for Feb.^y 1753. p. 77.

N.B. If the piece X moves or slides upon the slider GHIK, at the bottom by means of a screw like the poppets of a Watchmaker's Lathe, then may any length ~~betwee~~ be turned between P and E, provided GHIK be of a sufficient length. Moreover, if B, C, and E be short, especially in a small machine, I see no necessity for more of the poppets, A, and D than up to the slider GHIK, if they may not be entirely remove with the poppet C.

Let ABCD represent four poppets fixed on their frame: suppose in three, viz. ACD there are fixed brass sockets for the centers RM and EF, and the hollow mandril PO to move in; the center RM is fixed to the upright bar L, and the center EF moves by a screw in the upright bar X, and may be turned by the winch F; these bars are fixed to a sliding piece GHIK, which passes thro' the poppets, and moves on brass rolls the mandril PO, which passes thro' the poppet B, and turns in the center M, has a screw cut in it at S, which runs in a box fixed in the poppet B. As the string wrapped round the mandril at N, by means of the foot, causes the mandril to turn round, it is plain, it must move forward towards the center E; but the wood or iron, to be turned being fixed between the mandril P and the center at E, the wood, or iron, must move in that direction, and the center E be pushed back in its socket, and as the center E recedes, the center M must follow. When the foot is taken off then the mandril and wood, or iron, moves back again, and so on alternately. Let then a tool be applied on ~~the~~ a rest to the wood, or iron, to be turned; its evident it must be turned in the form of a screw: when you have turned it to your mind in one place, it is only moving the tool forward on the rest to another part: So by this method a screw may be turned of any length, and by alteration of the mandril, of any size. Yours &c. I. B. N.

Focus of Glass found by a Theorem, which corrects an error among Opticians.

There is an error, which I believe all your opticians in town fall into, with regard to the focus of glasses; I have been disappointed several times, the glasses I wrote for always proving a shorter focus than what I ordered; the reason of which I take to be this: They do not attend to the radius of convexity, or concavity of the tool they grind on, but depend on receiving the image of objects in the street before the shop, or the windows, &c. of the room on a piece of white paper, the distance of which from the glass they call the focus, or radius of convexity, but the radius of convexity is found by this equation $\frac{df}{d+f} = r$, where f = distance of the image from the glass, d = distance of the object from the glass, and r = true focus; the nearer the object made use of, the more the difference of their focus from the truth.

Trajectorium Lunare, a description & Use of it, by its inventor

Description of an instrument called the TRAJECTORIUM LUNARE, invented by James Ferguson Limner in London, for delineating the path of the Earth and of the Moon; shewing that the line of the moon's motion in the heavens is concave to the sun in every part of her Orbit.

In Fig. , AB represents a wooden bar about 8A inches long, to be turned by hand round the axis of the wheel CC, at A; the wheel being ~~kept~~ kept fixed by its spikes I, K, L, when softly pressed down on the floor of a room. The index D, fixt to the said bar, points

out the months and days, as it moves, on the fixed wheel CC. Round the edge of this wheel in a grove in the catgut string M M, crossing in the bar at N, and, going also in a grove, round the pulley G, which is fixed on the axis F, turns the pully with its axes, to which are fixed the black lead pencils e and m, perpendicular under the little balls E and M representing the Earth and Moon; carrying M round F in the same time as m round e. On this axis also is fixed an index, which in the same time goes round a small plate at B divided into 29½ equal parts, which are for the days of the moon's age. S represents the sun, whose center is 81 inches distant from the center of E the earth, from which the center of M the moon is $\frac{24}{100}$ parts of an inch distant, to keep the due proportion: for as 81 inches is to 81 millions of miles, the earth's distance from the sun, so is $\frac{24}{100}$ parts of an inch to 240 thousand miles, the moon's distance from the earth. The diameter of the wheel CC is to the diameter of the pulley G as a year is to a lunation; consequently in the time that the long bar is once moved round the fixed wheel CC, the index D will go over all the days of the months on that wheel, and the little moon M will describe as many revolutions round its earth E as the celestial moon does round ~~the~~ our earth in a year. And if a long paper be properly stretched on the floor, under the pencils e and m which move as E and M do, the pencil e (as in Fig.   , which is exactly copied from one of the figures in my harvest moon pamphlet, published in 1747) will describe the regular curve or line of the earth's annual motion AB, while the pencil in going round e will describe the line of the moon's path CD, which is concave to the sun throughout even at new moon; crossing the earth's path at the first and third quarters, lying betwixt it and the sun at new moon, and beyond it ~~at the~~ from the sun at full moon, as represented in the figure, where NM signifies new moon, 1 Q the first quarter, FM full moon, and 3 Q the third quarter.

In the Gents Mag: for May 1742. p. 265 is a description of an instrument, which makes the figure of the moon's path, instead of being always concave to the sun, turns off from it in a sharp angle at every new moon. The paths in different lunations appearing like so many segments of lesser circles joined together at their ends, with their angular points all turned towards one common center where the sun is supposed to be placed.

My scheme of the moon's path on large paper is sold by Mrs Senex at the globe opposite St Dunstan's church Fleet-street. Price 1s. 6d.

J. FERGUSON.

On Steel for Magnets, promis on p. 125.

All sorts of steel are not equally proper for making artificial magnets, The common English blister steel, and the rose steel are not amiss; that marked with an ace of clubs and an ace of hearts is better; but the best of all is a sort marked with a double spur and star. The rose and blister-steels will do best heated red hot, and then suddenly quenched in a large quantity of cold water; this succeeds well in small bars; but if the magnets are to be half or three=quarters of an inch thick, it will be very difficult to impregnate them with the magnetic virtue when they are thus

hardened, & case-hardening will do much better; however, if they are afterwards brought down to a blue, either way is indifferent.

A very good way is to make the bars of the double spur and star steel, and to heat each bar a little more than is necessary for tempering it, and then causing another person to hold it in tongs, stroke the sides of it from end to end with a piece of sopp till it cools. This temper is of such a quality as never fails to succeed.

But the best way of all is to heat the bars to a cherry red, & then to quench them in a good quantity of a solution of one part of armoniac in three parts of water; and then they will readily receive the magnetism, and retain it very strongly, especially if, after such tempering, they are hammered cold with a middle-sized hammer on a flat anvil.

Supplement to Gents Mag. 1766. p. 623.

Talbot's Micrometer, on p. 110. considered

To find the the Number of Threads in an inch of the screw for any given ~~length of~~ focus of an object Glass; or in plain sights, for the distance of the eye from the micrometer: & vice versâ. — 1. Put a = given focal length of the object Glass, or with plain sights, the eye from the hairs of the micrometer; T = tang.t of 15′, the angle subtended by any one of the hairs from the center in 30 revolutions of the screw. Then p Trig. 1 (Rad.) : a :: T : Ta = the distance of the hairs from the center of sight when the distance between both subtends an angle of 30′. Again, Ta : 30 Revolutions : 1 Inch : $\frac{30}{Ta}$ = N.o of threads in one inch. whereby the first of the following Tables was calculated.

2. Having the N.o of threads in an inch of the screw, given = r, to find the focal length of the object Glass. or, in plain sights, the distance of the eye from the hairs of the micrometer. r : 1 inch :: 30 revolutions : $\frac{30}{r}$ = the distance of the hairs from the center, when the screw has undergone 30 revolutions, & which subtends an angle of 15′; ∵ T : 1 (Rad.) :: $\frac{30}{r}$: $\frac{30}{Tr}$ = focal distance of the object Glass. or of the eye from the micrometer in plain sights. whereby the second of the following Tables was calculated.

Table I.st

Micrometer from y.e object Glass, or eye in pl. sights.	Threads of the screw in an inch, so as to exhibit Min.s and Seconds.	1.st Colm. continu.d Feet.	2.d Colum continued Threads.
2 Feet	286,477	13	44,0734
2½	229,182	13½	42,4411
3.	190,984	14	40,9253
3½	163,701	14½	39,5141
4	143,240	15	38,1969
4½	127,323	15½	36,9648
5	114,591	16	35,8097
5½	104,174	16½	34,7006
6	95,4924	17	33,7032
6½	88,1468	17½	32,7403
7	81,8306	18	31,8308
7½	76,3939	18½	30,9705
8	71,6193	19	30,1555
8½	67,4064	19½	29,3823
9	63,6616	20.	28,6477.
9½	60,3109		
10	57,2955		
10½	54,5671		
11	52,0868		
11½	49,8221		
12	47,7461		
12½	45,8364		

Table II.d

Threads of the Screw in an inch, so as to exhibit Min: & seconds.	Micrometer from the Object Glass; or eye in plain sights. Inches
15	458,364
20	343,773
25	275,020
30	229,182
35	196,442
40	171,886
45	152,788
*50	137,794
55	121,350
60	114,591
65	105,776
70	98,2207
75	91,6727
80	85,9431
85	80,8877
90	76,3939
95	72,3732
100	68,7545.
105	65,4805
110	62,5041
115	59,7865
120	57,2955.
*48	143,2386

3.d Instead of 30, in the 2 theorems above, write x for the N.o of teeth; then from the 1.st $\frac{x}{Ta} = r$, or from the 2.d $\frac{x}{Tr} = a$; whence $x = Tra$, the number of turns in the screw so that the last turn shall compleat 30′ of the micrometer: But since the tang.ts w.ch it describes are not as the arches or angles, the revolutions of the screw or each tooth of the wheel in this case of his will be of an unequal quantity; so that a Table must be calculated for every revolution, if not also for parts of a revolution to ascertain the seconds unless the hairs could be contrived to move in the arch of a circle, whose center shall be the focus of the object Glass; or, the eye itself in plain sights.

Talbot's Micrometer p.110. considered.

This last observation is Geometrically true, but so insensible that it cannot be regarded in practice; for the tangents and arches of the first 30 minutes, to a radius of about 9 Feet, do ~~so~~ very nearly coincide & increase together, as will appear from the following Table. To calculate which say 64 Threads of his screw : 1 Inch :: 1 Thread or turn of the Screw : ,015625 inch, 30 of which = ,46875, which subtends an angle of 15' to the Radius (107,429 inches (found by his analogy on p.110) the focal length of his object Glass; to which radius the quantity of every thread or turn of the screw I have calculated, as under, with their tangents to Radius of Tables.

Turns of Revolutions of the Screw	Tangents to Rad. of Tables, ~~of~~ at each turn of the screw, from the center.	Quantities of those tangts described by one hair from the center.
1	,000145445	0 .. 30
2	,000290890	1 .. ·
3	,000436335	1 .. 30
4	,000581780	2 .. ·
5	,000727225	2 .. 30
6	,000872670	3 .. ·
7	,001018115	3 .. 30
8	,001163560	4 .. ·
9	,001309005	4 .. 30
10	,001454450	5 .. ·
11	,001599895	5 .. 30
12	,001745340	6 .. ·
13	,001890785	6 .. 30
14	,002036230	7 .. ·
15	,002181675	7 .. 30
16	,002327120	8 .. ·
17	,002472565	8 .. 30
18	,002618010	9 .. ·
19	,002763455	9 .. 30
20	,002908900	10 .. ·
21	,003054345	10 .. 30
22	,003199790	11 .. ·
23	,003345235	11 .. 30
24	,003490680	12 .. ·
25	,003636125	12 .. 30
26	,003781570	13 .. ·
27	,003927015	13 .. 30
28	,004072460	14 .. ·
29	,004217905	14 .. 30
30	,004363350	15 .. ·

4. It appears to me that this micrometer may be adapted to all Radii & Screws. thus.

1st Suppose only a pin at e fig. 12. then, had his Screw been only 32 threads to an inch, the wheel f might have consisted of ~~30~~ or, of any ~~number of~~ 30 teeth as before, other number; but the index i then describing 2 Minutes in every revolution the plate, upon which the index a shews the seconds, must be divided into 120 equal parts: ~~[illegible] f might have consisted of 15 teeth & the plate shewing [illegible] divided into 60 parts, because the [illegible] revolution of i would be a minute~~. Again, Suppose ~~the~~ his screw of $\frac{64}{5}$ = 12,8 threads to an inch, the wheel f might ~~be~~ contain ~~[illegible]~~ 6, or any other number of teeth, for i to shew a minute in a revolution, & the plate at a divided into 60 ×5 = 300 parts for seconds: Also, had his Screw contained 128 threads in an inch, the wheel f might contain any number of teeth, but the plate at a divided only into 30 equal parts for seconds, because the index i turns twice round in a minute.

2. Suppose now a wheel at e instead of a pin only, then may Minutes and second be shewn ~~only~~ by inspection only with a screw ab containing any given number of threads in an inch. Thus, Adapt the two wheels at f and e so as the index i may, in one revolution, describe one minute which striking another wheel of 30, ~~teeth~~ 31, or 32 teeth to count its number of Revolutions or Minutes, and then itself shewing seconds upon the plate AB (under it) divided into 60 equal parts.

Examples. 1. Suppose I have a telescope, whose object Glass hath a focus of 2 feet; this by table on p. 128 requires a screw of 287 ~~teeth~~ threads in an inch, which is impracticable, & my Screw hath only 41 ~~teeth~~ threads in an inch. which is exactly 7 times to few; therefore the index i must make 7 revolutions whilst the Screw ab makes one: whence if the wheel at e contains ~~[illegible]~~ 42 teeth, and that working in it at f ~~[illegible]~~ 6 teeth, then i. goes one round in a minute, driving another wheel of any convenient No. of teeth so as to tell or count the revolutions of i; which i. also shews the seconds upon the plate under it divided into 60 equal parts

Example. 2. Suppose the focal length of the object Glass 20 Feet. & my Screw 58 threads in an inch: I find by calculation that one turn of the screw is only half a minute; therefore ab must go twice round to a minute. From whence the wheel f must ~~be~~ have 12 teeth, double that of e, of 6 teeth only: rest as before, in the last example. — N.B. the index i may turn twice round in a minute, if it should be required in any case, and the wheel which it turns must then have 60, 62 or 64 teeth, number every other for minutes, & those between will be ½ min. the seconds of which ½ minutes will be shewn upon the plate under i. divided into 30 pts.

Talbot's Micrometer considered.

An inconveniency therein, remov'd.

This index i Shewing the seconds upon the plate AB under it, and driving another wheel for minutes or N.° of its revolutions, gains a great Space from the bottom A & thereby admitting the circle upon the plate for seconds of a considerable Radius; whereas Talbot's method of shewing Seconds by the index at a must be from a circle of a small diameter upon the plate, because the Screw ab must be so near the Edge AA as to be out of the field of view.

131 An Essay for finding the Longitude at Sea, by Michael Woods, Mathematician in Liverpool. Gents Mag. for Septr. 1767. p. 449.

Having observed several essays for finding the longitude, I have sent you one which differs from them all.

The notion that some machine must be contrived to measure exactly the space of a solar day, commonly supposed to contain 24 hours, hath hitherto, in my opinion, defeated every attempt to discover the longitude by a time-keeper, a thing neither necessary nor practicable with any certainty, by reason of the inequality of the solar days: for the time between one meridian shadow, on a sundial, and the next, is not equal, and that inequality is ever more or less, according to the sun's position in the ecliptic, &c.

The only probable machine that has been made, is by one John Harrison, finished about Christmass 1765, which machine I went to see at Greenwich.

But as I apprehend, the only portion of time necessary to be measured, is that of the earth's diurnal motion on its own axis, which, by the following directions, may be determined with great exactness.

As the earth's revolutions upon its axis, from west to east, are ever equal in time one to another, so all fixed stars, whether they rise or set, or are always above the horizon, if observed from any particular place, must appear to revolve in the same equal time.

Provide yourself, therefore, with a sand-glass, large enough to contain such a quantity of sand as shall take up that whole period in running out, so that the glass need ~~not~~ be turned but once to each revolution. Being provided with such a glass, take a small tube, whose diameter must not exceed the apparent diameter of a star, turn it in the night to any fixed star that may suit your purpose, and the moment you have the center of the star against the center of the tube, fix your tube fast, causing the glass to be turned at the same instant. The next night note if the sand in your glass is all run out, or not, at the time the same star comes again opposite to the center of your tube, which must remain all the time as at first fixed. Repeat your observation in the same manner every night, till you bring it exactly to the time required. Your glass being thus regulated, for the method of using it at sea, in order to know your longitude observe this ~~most~~ general and most useful rule. Observe any two fixed stars near the elevated pole, whose right ascension is the same; or any two whose difference of right ascension is 12 hours; the first always comes on the meridian at the same time, either above or below the pole; the latter likewise comes on the meridian, but have always the pole between them; either will do. The star in Cassiopeia's side, the polar star, and the last but two in the Great Bear's Tail, come on the meridian near the same time. When you find two stars you intend to Observe are near the meridian, hold up a thread and plummet; note, when they cut the thread, and at that instant cause your glass to be turned; then, if you continue on the same meridian, you will find that your glass will be always out when those stars come perpendicular to the thread and plummet, or on the meridian; but if you move to the eastward or westward, the difference will be equal to your difference of longitude east or west.

I have tried thus to suspend a plummet & line on board, but find it utterly impracticable. MP.

As the polar star is never above two and a half degrees from

the meridian of any place, it will be of perpetual use for observations in the northern hemisphere, and any noted stars, when on or near the meridian, may be observed with it, it not being material whether the stars you observe by be directly on the meridian or not, provided they are near it; all that is required being such a position as can be determined with certainty. The two pointers in the Great Bear will be of excellent use, they being on the meridian near the same time: in short all the constellations above the pole afford proper stars of the second magnitude, viz. Auriga, Perseus, Cassiopœia, Cepheus, Little and Great Bear, &c. so that all times of the year you will have stars for your purpose, either above or below the pole, as suit best with your latitude: for note, that if your latitude be less than 35 degrees, stars on the meridian, above the pole, may be best observed; but if more than 35 degrees, then those below the pole are best. In the same manner may observations be made in the southern hemisphere. There are two stars in the Crosiers, whose right ascension is the same, according to Dr Edmund Halley's observations: There are likewise other constellations about the south pole that I am not acquainted with, which, no doubt, will do as well as those in the northern hemisphere, and be worth the notice of those who sail in those parts.

Now to illustrate this by an example; suppose a ship at Liverpool ready for departure, on the 1st of April, for the continent of America; as, at this time, the first star in Orion's belt cannot be seen, one must therefore be taken near the pole, which, as the pole is here elevated a little above 53 degrees, will suit best on the meridian under it, and may be found in Cassiopœia's side at eleven o'clock at night. Being provided with your sand-glass, regulated as above directed, observe carefully by your thread and plummet when the star comes on the meridian, or rather right under the polar star; the moment the thread cuts both stars, cause your glass to be turned, and proceed on your voyage; you will then have these three particulars always given, viz. your sand-glass being always regularly turned the moment it is out, will shew the time when those stars come on the meridian of Liverpool, or place departed from; your thread and plummet will shew when they come on the meridian of the place the ships is in; and a good watch, or spring clock, will shew the time between, with sufficient exactness in hours and minutes, which is the angle at the pole, ever equal to the difference of longitude.

Now after twenty days sailing, we will suppose that the aforesaid stars come on the meridian of Liverpool, or place departed from, two hours and 45 minutes before they come on the meridian of the place the ship is in; or, which is the same thing, that your glass is turned two hours 45 minutes,

before those stars come to the same position by your line and plummet, as when first observed at your departure; hence you may conclude your difference of longitude to be 41 degrees 15 minutes westerly, two hours 45 minutes reduced to degrees and minutes, being equal to 41 degrees 15 minutes. Note, if your glass be out before you have your observation, the difference of longitude is westerly; and, on the contrary, if you have your observation first, the difference is easterly. Thus you may settle your longitude every clear night, and if due care be taken in turning the glass, you will not have an error therein of 15 minutes in the longest voyage, for the observation may be always made in less than half a minute of time.

By decreasing your latitude, the star you took your first observation by, at departure, may be depressed below the horizon; or, by length of time, may come on the meridian before night; in either of which cases, it is but taking your observation in time by some other star, more convenient to your purpose, and turning another glass, as at first, and your journal may be continued with the same exactness as if you still made your observation by the same star. It may possibly happen that the sand, continually running for a long space of time, may wear the orifice thro' which it passes; or the grains, by rubbing against each other, may be so polished as to run something faster than at first; but this may be easily tried and remedied by spare glasses, of which it will be necessary for every captain to have two or three at least, as well on this account as on account of those above mentioned; which, as the expence is small, can be no great inconvenience. The only objection that occurs to me, against this method, is, its being impracticable beyond the polar circles, by reason of the sun's continuance there above the horizon, the only time when those seas are navigable; but, as they only include a small part of the world, and few ships frequenting those parts, I think it can be of no great weight. Thus the main point of navigation may be determined, without any regard to the solar time.

Friday 11th of 7ber. Gent's Mag. p. 475. for Septr. 1767. New accurate instrument for celestial observns.

The Abbe Rochon, who sailed from Brest in April last, in order to make trial of some instruments of his own invention, for taking Altitudes at Sea, returned from his Voyage, in course of which he had observed several eclipses of Jupiter's satellites: and it is asserted, that by his instruments the observer can never be above four seconds without recovering the star, let the motion of the ship be ever so violent, which must be of infinite advantage in making observations for discovering the longitude at Sea.

Jupiter cast an elliptical & not a circular shadow, by De la Lande.
See p. 9.

M. de la Lande, in a memoir of the History of the Royal Academy of Sciences at Paris, for the year 1763, treats of the difference produced, by the oblate figure of Jupiter, in the semi=durations of the eclipses of his satellites. He shews the necessity, and ascertains the quantity, of a new correction, relative to the theory of these satellites, arising from the consideration of the elliptical figure of Jupiter's shadow, which hath hitherto been considered as circular. By this correction, the theory of the satellites is cleared of an inequality, evidently too con=siderable to be neglected; as the semiduration, deduced from the supposed circular section of the shadow, differs from that drawn from the true elliptical figure of it (when the difference is greatest) 1'. 33" for the first satellite; 2'. 14" for the second; 1'. 13" for the third; and with regard to the fourth, an error of no less than 2 months may be ~~comm~~ committed, in ascertaining the time when it ceases to be eclipsed, by not attending to this correction.} Monthly review {for Sept. 1767. p. 171.

Experiments on the burning of Candles and Lamps.

Experiments to determined the expence of burning Candles of different sizes, as they are commonly made at Market-Harborough, in Leicestershire.

Experiments to ascertain the expence of burning Chamber oil. — A taper lamp, with eight threads of cotton in the wick consumed in one hour, ,325 oz of spermaceti oil, at two shillings and six-pence per gallon; the expence of burning 12 hours is 4,57 farthings.
N.B. This gives as good a light as the candles of eight and ten in pound. This lamp seldom wants snuffing, and casts a steady, strong light.
A taper, chamber, or watch lamp, with 4 ordinary threads of cotton in the wick consumes ,1664 oz of spermaceti oil in one hour; the oil at 2s. 6d per gallon; the expence of burning 12 hours is 2,34 farthings. Gent. mag. for Feb. 1765.

	Candles in one pound	Weight of one candle		Time one candle lasted		Expence in 12 hours at 6d per Dozen.
		Oz	Dr.	H	M	farth. & 100th part
A small wick —	18½	0	14	3	15	4,85
A large Do. —	19	0	13½	2	40	5,70
	16½	0	15½	2	40	6,54
	12	1	5½	3	27	6,96
	10¾	1	8	3	36	7,50
	7¾	2	1	4	9	8,94
	8	2	0	4	15	8,47
	5¾	2	13	5	19	9,53
						Do. at 6½d p Doz.
	12	1	5⅓	3	39¼	7,30
	8	2	0	4	44	8,42
	6	2	10⅔	6	34	8,06

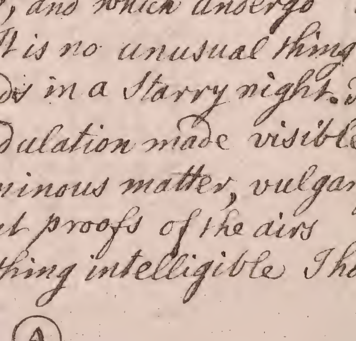
In the winter 1766 I myself found the mean burning of each candle from the time of the whole 8 in the pound for 3 successive pounds to be $4^{H}\,41^{M}$, $4^{H}\,35\frac{1}{3}^{M}$ & $4^{H}\,54\frac{1}{2}^{M}$. The mean of these 3 again is 4. 44. — The mean for each candle from a whole pound of sixes is $6^{H}\,34^{M}$ and for one from a whole pound of twelves is $3^{H}\,39\frac{1}{4}^{M}$. Which & their appurtances are put down in the three last lines of the Table

(135)

The phænomenon of the Horizontal Moon attempted upon new principles.

Mr. Urban,

As I was walking one evening upon an hill near this town, the phænomenon of the horizontal moon, took up my attention. The evening was clear, and with a quadrant I measured the angle it subtended to the eye. Soon afterwards a fog arose, and upon a like mensuration I found the angle considerably less. I began to consider, whether this accident of the fog might not in some measure afford a solution of this phænomenon, so frequently and so unsuccessfully attempted. Molineux in his dioptrics, Smith in his optics, Rowning and other sages of natural philosophy, seem to have proceeded upon wrong principles. They have endeavoured to account for the moon's magnitude in the horizon, without considering the nature and state of the medium through which we view it. Now it is a most evident principle in physics, that the vapours arising from the surface of the earth, while they are near the surface, are in a state of rarefaction, and are not in that of condensation, till they arise at the superior parts of the atmosphere. That they are rarefied near the surface is plain from their easy dissipation, when the least flux of air agitates and impells them. That they are condensed in the upper parts of the atmosphere, is plain from their formation into clouds, and meteors. If we look at the moon in the horizon, we guide our eye in a direct line over the surface of the earth, and consequently view the moon through a medium, that suffers little or no obstruction from the spissitude of vaporous particles. If on the other hand we view her in the meridian, we look at her through a dense, gross medium, in which a great part of the emissive efficacious rays are absorbed, and by a known rule in optics, where the rays that should be efficacious are less transmitted to the eye, the less will an object appear, or the appearance of an object will be less than it should be: yet we well know, that the meridional moon should appear larger, according to optical reasoning, than the horizontal, because the meridional is nearer to us by almost a semidiameter of the earth. But it will be said, how can we be said to view the meridional moon through a dense medium, when we generally see her, if at all, in a clear sky. Here lies the deceit. We think the sky is clear when we see no clouds. Clear indeed from clouds, but at the same time replete with vapours: Vapours of a different kind from those which constitute clouds, and which undergo a considerable degree of condensation. It is no unusual thing to experience this, when we look upwards in a starry night. Those coruscations in the atmosphere, that undulation made visible by the stars, those scintillations of luminous matter, vulgarly called the falling of a star, are sufficient proofs of the airs redundancy in vapours. To make the thing intelligible I have drawn the following scheme.



A is the meridional moon, B the horizontal, D the surface of the earth, CD a space within which the superficial vapous fluctuate, F the eye of the spectator. When the eye of the Spectator is directed forwards towards the horizon, the space CD abounding with few, if any, vapours that are infinitely rare and expanded, and whose component parteles consequently cause no sensible alteration in the medium of air; unless it

it be, as it sometimes happens, that they become fogs, and condense near the surface of the earth; in such a ~~state~~ situation the eye will see the moon as big as B. When the eye is directed upwards to the moon in the meridian, the upper regions of the air abounding with condensation, it will see the moon as small as A. The following experiment seems to confirm this hypothesis. Take a bason, and fill it with clear water: when so filled, put in half a crown or any piece of that size, and take its apparent diameter, as it offers it to the eye from the bottom of the bason. When you have done this condense the medium of water with two or three spoon-fulls of red wine, milk, beer, or any other liquid, but not so much as to make the medium opaque, putting in so much only as will still keep it pellucid. In this case, and under these circumstances of consideration, to an attentive observer, the apparent diameter will be considerably lessened.

Experiment to prove that an object appears less thro' a dense medium than a rarer. which contradicts the received notion & the known rules of Optics.

I don't know that this phænomenon, so much the wrangle of the schools at Cambridge, has been accounted for on these principles. May your philosophical correspondents improve upon this hint, and endeavour to draw aside the veil that has hitherto concealed this truth from the sons of science.

High Wycombe
Bucks. Sept. 9th

I am yours &c

EDGAR BOCHART.

Gents Mag. for Octr. 1767. p. 494 & 5.

A Nautical Foot is 13,8258 English Inches; this divided into 12 equal parts, each will be a nautical inch.

The Ratio of a Paris foot to an English foot

It is generally allowed that a Paris foot exceeds an english foot by 9 lines. Sir I. N. in his Principia p. 378 l. 31 & 32. 2nd Edit. Lib. III. prop. 19. makes 367196 English feet = 57300 Toises; wherefore ~~367196~~ 53700×6 feet at Paris: 367196 feet Eng. :: 1 foot Paris : 1,068053 fere, the measure of a Paris foot in Engl. measure; and 4943,576 Paris feet (4944 = 3,6940412) = 5280 Engl. = 1 Mile; But at Page 381. l. 9. He says 5000 Paris feet = one Mile; ∴ 5000 : 5280 :: 1 : 1,056, for a Paris foot in English measure, which I do not find used by any other author; but they always make use of 1,068. Which I therefore have follow'd in reducing the following French Measures to English Miles.

Gent. Mag. Vol. XIII. p. 142. and also a French Author, say, that "A Paris toise is equivalent to 76,6 English Inches." ∴ 1,064 fere English Inches is a Paris foot. But in Philos. Trans. Vol. L. XLVIII. p. 326. it is 76,734 inches Eng. = a Toise. & as 1 : 1,06575 :: a P. F.: a F. F.

Measures of a 1° on the ⊖, and its dimentions thence deduced.

No.	Name of those who measured	Measured From: Place	From: Latitude	To: Place	To: Latitude	Difference of Latitude	Length of their whole measure.
1.	Picard	Amiens	49. 54. 46	Malvoisine (Malvcin)	48. 31. 48	1 22 55	78901,3 Toises.
2.	Norwood	London.	51. 32 N	York	54. 0	2. 28. 0	English Feet 905751
3.	Cassini	Paris	48 39 N. / 48° 50′ 10″ Hist. of R. Acad. of Sciences.	Colours / Collioure	42. 21 / 42. 31. 13″	6. 18. 0 / 6. 18. 57	360634 Toises & 57100 to a 1°
4.	Messrs. de Maupertuis, ~~Clairaut~~ Clairaut, Camus, Le Monier, The Abbé Outhier, & M. Celsius of Uspal	Artic Circle & their middle Lat = 66°. 31 N.	Midd. Lat 66-31 N		Midd. Lat. 66-31 N	1. . . .	57437 Toises
5.	Who corrected Picard's Nos						
6.	De la Caille	Klipfonteyn	32. 41. 57⅔ S.	His Observ.	33. 55. 15	1. 3. 17⅓	Toises 69669,1

In My Complete Dict. they make the ⊖'s Polar Semidiam. = 3931,6 Miles & Equatorial diam. = 3975. See p. 9. De La Caille, in his Astron. p. 191. Art. 425. Makes ⊖'s Semidiam. = 19611500 Paris feet = 3967,068 Engl. Stat. miles.

No.	Measure of one deg. on the Merid. deduced from the Observations above: ~~Toises~~	Logarithm	Engl. Miles	Logarithm.	Semidiameter of the ⊖. Engl. Miles	Logarithm	Circumf. of ⊖ in E. Miles
1	57060	4,7563318	69,25351	1,8404419	3967,935	3,5985645,3	24931,27
2	57300	4,7581546	69,5448	1,8422647	3984,624	3,6003873,3	25036,13
3	57292	4,7580940	69,5351	1,8422041	3984,069	3,6003267,3	25032,64
4	57437	4,7591917	69,71108	1,8433018	3994,151	3,6014244,3	25095,98
5	56925	4,7553030	69,08966	1,8394131	3958,547	3,5975357,3	24872,28
6	57037	4,7561567	69,29562	1,8402668	3966,335	3,5983894,3	24921,23
	57,037 5/6		69,33329		3975,943½		24981,59

[illegible] marked with a red line [illegible] the No. 4 of [illegible] of the Royal [illegible] Sciences at [illegible] M.

The Mean of all 6

Essay towards finding the Longitude at Sea.

1st. Let it be granted, that by the help of the sun, or stars, the precise time of the day, or night, may be known, whereever a ship may be, with sufficient exactness.

2d. As at present, every system of navigation contains a table of the suns declination, for every mid-day, calculated for the first meridian, for a certain number of ~~years~~ to come; that is to say, the sun's place, or rather the earths place in the ecliptic, is pointed out for every mid-day. Therefore it will be readily granted we hope, that a table may be ~~found~~ formed, containing the meridian that will be in the Zenith of London, for every mid-day, every hour, and second of time, for any desired time to come.

These things being premised, let the mariner be provided with such a table; and with another table, containing the right anscension, declination, and celestial longitude, of all such fixed stars, as are easily observable by the naked eye.

Then every sailor may know at once (his latitude, and) what meridian is in his zenith, every time he observes the culmination of any known star; elevated at least, thirty-five degrees above the horizon, which he may do, by the help of a good quadrant; or by finding the difference, between the magnetic and true meridian. It is taken for granted that he knows the time of its culmination, with sufficient exactness. And it is certain, that the longitude sought, must be, the distance between the meridian in his zenith, at the time of observation, and the meridian in the Zenith of London, at the same time of the same day, and what that distance is, he finds, with one glance on his tables.

The author conceals his real name, under the fictitious one of

WIEMW BRITANNICUS.

P.S. It is hoped, proper judges will allow this plan to have its foundation laid in truth, and in that case, the following considerations will naturally recommend it, viz. That no Time keeper is necessary to discover how that time passes, at the first meridian; neither is a marine chair necessary in taking observations of heavenly objects, easily perceivable by the naked eye; and when neither sun, ~~moon~~ moon, Jupiter, nor Mercury can be seen, observations in abundance may be had from some or other of the numerous tribe of fixed stars, whose place in the heavens change not, as that of all the planets do.

Gents. Mag. Nov. 1767. p. 540.

The Descent or fall of Water in Rivers.

"The ingenious Mr Smeaton, in a report delivered last year to the trustees for improving the navigation of the river Lee, observes that the descent or fall of that river, during a course of more than thirty-one miles, is one hundred and eleven feet, or something less than one mile in 1760." Monthly Review Nov. 1767. p. 376.

139) Difference between Amphibious & land animals.

"The essential difference (as to the general structure of the heart) between amphibious and meer land animals, or such as never go into the water, is that the foramen ovale remains always open; thro' this is a communication, and the circulation is kept up, tho' the animal does not respire while under water." Monthly Review for Decr. 1767. On a No. of the Philosop. Trans. for 1766.

How the circulation in the fœtus is carried on.

"The blood brought by the vena cava into the right auricle of the heart takes three different courses in the fœtus. One part goes directly from the right auricle through the foramen ovale into the vena pulmonalis; and thence into the left auricle, without passing through the lungs. The other part goes from the right auricle into the right ventricle of the heart, and thence into the pulmonary ~~artery~~ artery: this again is divided into two courses; one part proceeds from the pulmonary artery, into the aorta descendens, through the canalis arteriosus; and what remains, is sent through the lungs by the ramifications of the pulmonary artery. — Hence it is evident, that in the fœtus, but a small proportion of the blood passes through the lungs themselves; which are as yet collapsed and in a great degree impervious. After birth, however, in meer land animals, respiration takes place, the passage through the lungs becomes free, and the foramen ovale, with the canalis arteriosus, are closed. Hence the whole mass of blood must necessarily after this pass through the lungs: and consequently whenever respiration ceases, and this passage through the lungs is obstructed, wheter from immersion in water, or from any other cause, the circulation is suppressed, and death must immediately ensue." Do. p. 444. being a Note of theirs to explain the last passage.

Among "Curious Anecdotes of Rome, Naples, Florence, and Genoa: By a Swedish Traveller," in the Gents Mag. Feb. 1768. p. 51. is the following on p. 52.

Marble stained quite through.

"The prince de San Severo is famous at Naples for his many discoveries in chemistry. He has learned to give white marble a fixed tint of any colour; a tint, which penetrates the whole mass, how thick soever. What is still more surprizing, is a cube of white marble two foot square, on one side of which is painted a figure of the virgin, which is found on all the leaves that are sawed from the block. This prince has also discovered the secret of the inextinguishable lamps of the ancients."

Inextinguishable Lamps discovered.

In a description of the Island of Anticosti, by T. Wright, who wintered on, & surveyed that Island, By order of Government. In Gents Mag. Feb. 1768. p. 63.

Situation of the island Anticosti.

"The island of Anticosti is situated at the entrance of the river St. Lawrence, between the parallels of 49°. 4' and 49°. 53'. 15" N. latitude and the meridians of 61°. 58' and 64°. 35' West longitude from London determined by ten observations on the eclipses of Jupiter's first satellite. Its circumference is 282 statute miles, its length 129 miles, and its breadth from 32 to 12 miles. This island contains 1699840 acres of very indifferent land." — ~~p.65~~ — p. 65. " The winter that we spent on this island was very

Great Cold & Snow there.

very severe, there being frost at different times, from the 15th day of September, to the 21st day of June following, on which day I broke a thin skin of ice on a pond, and on the 31st day of May measur'd a bank of snow which lay near the sea, eleven feet perpendicular height, and half a mile in length. We had two continued frosts night and day, the last from the 14th day of November to the 6th day of January; and the other from the 12th of the same month, to the 23d day of March following; during each of these set frosts, the thermometer was from ten, twenty, thirty, to forty seven degrees below the freezing mark, and the sea seldom to be seen for the quantity of ice & snow which was spread over its surface."

Expansion of Metals. v. p.92. and 155-7. also p.4–

In the hist. of the Royal Acad. of Sciences at Paris, for 1703, from a very accurate experiment by M. de la Hire, it appears, that a bar of iron 6 feet long when exposed to the frost in winter, gained or expanded $\frac{2}{3}$ of a line, when exposed to the heat of the sun in summer. And in the same memoir he says; M. Picard having exposed bodies to the frost, and putting them afterwards near the fire, observed a prolongation of $\frac{1}{4}$ of a line, in the length of a foot; which gives $\frac{3}{4}$ of a line in the length of a pendulum: but he found only $\frac{1}{3}$ of a line, in exposing the bodies to the sun the following summer.

The uncertainty of measuring this expansion, & a universal standard measure proposed. Largely treated of in Dr. Hooke's Posthumous Works p. 458. & p. 472.

He goes on & shews the uncertainty of measuring this expansion, from the standard measure suffering the same effect: for an iron rod of 3 feet at Paris was prolonged $\frac{5}{4}$ of a line at Cayenne, where the length of a pendulum beating seconds ~~[illegible]~~ measured there with this rod, would be found shorter than at Paris by $\frac{5}{4}$ of a line, tho' in reality it was the same in both places. So at Goreè this rod or measure was prolonged 2 lines more than at Paris; the length of the pendulum beating seconds, measured with this rod, must therefore appear shorter than at Paris by 2 lines. "If it was so, the universal measure of the "pendulum would remain always the same, over all the earth, "and the particular measure should be regulated by this measure, "taking the length of the simple pendulum for 3 feet, or $\frac{1}{2}$ a toise."

Martyn's & Chambers's abridgement, Vol. 2. p. 110, & 111.

The same is proposed in Question 205. page 875. of Martin's Magazine Vol. 2. for the year 1758. by R. Waddington of Hull. who in the Jan.y Mag. following answers it thus

By the Newtonian philosophical principles of the mathematics, I find the length of pendulums vibrating seconds in the Latitudes as follows, viz.

	Latitude	Length of Pend. Inches French.	Length of Pend. Inches English.
Paris, at the observatory	48. 50	36,7134	39,161
	50	36,7161	39,164
	51	36,7188	39,167
London, the Tower	51. 32	36,72	39,168
	52	36,7215	39,170
Cambridge	52. 17		
	53	36,7242	39,173
York, at the Castle	54	36,727	39,176
	55	36,7297	39,178
Edingburgh, Scotland	55. 57	36,732	39,180.

The Latitude of the place being known, and having a good pendulum clock adjusted to vibrate seconds in a temperate air, the center of

141) oscillation of the pendulum, may be had by Mr Emerson's Fluxions, 1st Edit. page 230, or 2d Edit. p. 319. Or by his Mechanics, 1st Edit. p. 87. Then measure this distance of the centers of suspension and oscillation; lay it upon a good plain surface (provided for that purpose) which done, and a line drawn in a right direction therefrom, the length whereof is known from above, or from the Newtonian principles of gravitation, &c. which length divided into Feet, Inches and parts, and you will have a universal measure. R. Waddington.

It may, perhaps, be worth while to collect all the observations & experiments, made upon the vibration & length of pendulums in different latitudes & climates, in order to ascertain what may be attributed to the effect of heat & cold; and what powers of gravities arising from different figures from the different ~~figure~~ of the Earth, which (figure) it is said, they (Pendulums) have so much verified. But we ought also for this purpose, to be furnished with the states of the theremometer during the time of the observations, which is a thing rarely to be met with. However I shall reserve the rest of this page and the following for such as I shall meet with in the course of my reading.

~~From~~ the most accurate observation of Jupiters satellites, by M. Couplet the son, Abbot Bignon, president of the royal academy of Sciences at Paris, made at Lisbon & by M. Cassini made at the observatory at Paris. May 7. 1698. the Difference of Meridians was 0H. 51m. 51s. = 12°. 57'. 45", whereby Lisbon is more easterly than Paris. Supposing Long. of Paris 21° only, that of Lisbon will be 8°. 2'. 15". The former gentleman M. Couplet, observed the greatest & least Altitude of the Polar star in the end of December 1697 & thence deduces the apparent Alt. thereof or Latitude of Lisbon 38°. 45'. 25". — Before he left Paris, he regulated his clock, beating seconds, at the Observatory in July & beginning of August 1697: which continued to go with the mean motion a considerable time that he might be assured of the just length of his pendulum. He left it in this state, & set it agoing at Lisbon the Nov. following & found it lost 2'. 13" in 24 Hous, & ~~required~~ the pendulum required to be $2\frac{1}{2}$ lines shorter at Lisbon than at Paris.

This same gentleman, in March 1698 by the same methods, settled the Lat. of Paraiba in Brazil, to be 6°. 58'. 18" South. Then he put his pendulum into the same state as when he left Paris, & found it lost of mean motion 4'. 12" in 24 hours, & required to be shorther at Paraiba than at Paris by $3\frac{2}{3}$ lines. He then put it into the same state as when he used it at Lisbon, which then lost 2'. 5" in 24 hours. at Paraiba. The length of his pendulum at Paris was 3 feet 8 lines $\frac{1}{2}$; At Paraiba 3 feet 4 lines $\frac{5}{6}$; & at Lisbon 3 feet 6 Lines, when it vibrated seconds.

Memoir 4, of the Royal Academy of Sciences at Paris, abridged by Martin & Chambers Vol. I. p. 230 to 234.

M. de la Caille, from the result of many trials, in 1751 & 1752, found the length of a simple pendulum, at 33°. 55' of South Latitude, to be 3 feet 8,07 lines of the Chatelet of Paris. Gent's Mag. for Nov. 1755. p. 512.

Peruse Newtoni Principia lib. 3 Prop. 20. p. 382.

M. Richer, having regulated his pendulum-clock at Paris, to the mean motion of the Sun; went to Cayene in 1672 to make Astronomical Observations, and there found it lost every day 2 minutes and 28 seconds. This island is not above 5 degrees distant from the equator. He reported this experiment in France, and it became the object of the attention, and disquisition of all the Philosophers and mathematicians. "They immediately saw, that in consequence of this experiment, the pressure of gravity was less at Cayene than at Paris." — — For though[a] in warm climates, it is true, the rod of the pendulum lengthens, as all rods of metal do, consequently its oscillations are retarded; for the longer the rod is, supposing an equality in other respects, the slower are its oscillations; but we know pretty exactly, how much heat lengthens pendulums; and, consequently, how much it retards their motion

Philosophic Queres

The same are in Nature Displayed 8vo. 1734.
Vol. IV. Dialog XI. p. 147. &c. Or Nature Delineated
Vol. IV. ~~Dialog~~ Discourse XI.

1. Warmth ~~is~~ felt in a dark place. The light may be permitted in a place & yet the place excessive cold. a dark chamber heated by a stove. it will continue dark. Quere is not here *light* without *heat*, and *heat* without *light*?

2. The moon lighteth resplendently, but not heateth. Quere?

3. The Top of the Alps, peak of Teyde in the Isle of Teneriff, summit of Condeleras ~~of~~ peru in the heart of Torrid Zone is sharpest Cold with the brightest light. is not here *light* without *heat*?

4. Rays of the moon contracted by a focus of five hundred times brighter than the full moon, warms nothing, nor raises the least motion in the Thermometer. is not here *light* without *heat*?

5. Crystal Glass & precious stones full of light, but cease being so as soon as red hot. can this *heat* be *light*?

6. If light was heat we should have excessive heats *before* the solstice, as *after*, & in *may* as in *July*. would not this be the case?

7. The body of light an immense fluid always about, but not always moved & vibrated as far as us. it may be vibrated, driven, by the sun, by a conflagration, a flambeau, a spark, & all inflamed bodies, but is not the production of them. Hence undoubtedly Moses begins his Account of the Creation with the body of Light. Is not this the case?

8. If the Lanthorn on the tower of Messina is the perceived in the space of only eight cubic leagues, itself in the center, it fills the whole space. if a lanthorn be darkened, the light disappears, but when uncovered fills the said space with *new* light instantly, what an immense quantity of light must be *produced* from this lanthorn in one Night. can this be true?

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hath those of Light & Heat, I would call *Air quiesent*: so that *Fire in orb* & *Air quiesent* are the two extremes of all the intermediate states & conditions of one & the same elementary fluid. This contradicts Jo[illegible] opinion p. 16[illegible] 161, 162. and Dr. Hales's his Thoughts on God & Nature p. 322 to 342. See also Hillary's Laws of the motion of Fire. Dr. Desaguliers philos. Konenning's Crocker's Dictionary under Fire. ~~[illegible]~~ Philos.
[illegible]

9. As the air exists before the bell strikes it, so the light exists
about the Spharos of messina before the erecting of the Lanthorn
wanting only the action of fire to make it visible. why may not
this be true?
10. As the air forms no Emanation from the bell that ~~[illegible]~~
~~it~~ strikes it. why should the light from the sun or any other
luminous Body?
11. If light was a production of luminous bodies the Owl &
othe nocturnal animals could not see in the night. The pupilla
of the Owl is susceptible of great dilitation, whereby its Eye
assembles a great quantity of that feeble light. The Cat still
passes for being the rival of the Owl in this faculty: as
also the Mole in its subterraneous abode. can these
Animals be said to see by the help of luminous bodies?
12. A piece of Iron hot enough to burn casteth no
light, why?
The sole end of all these queries is to determine
1. whether Light is an emanation from luminous
bodies. 2. And whether Light & heat are one & the
same thing.

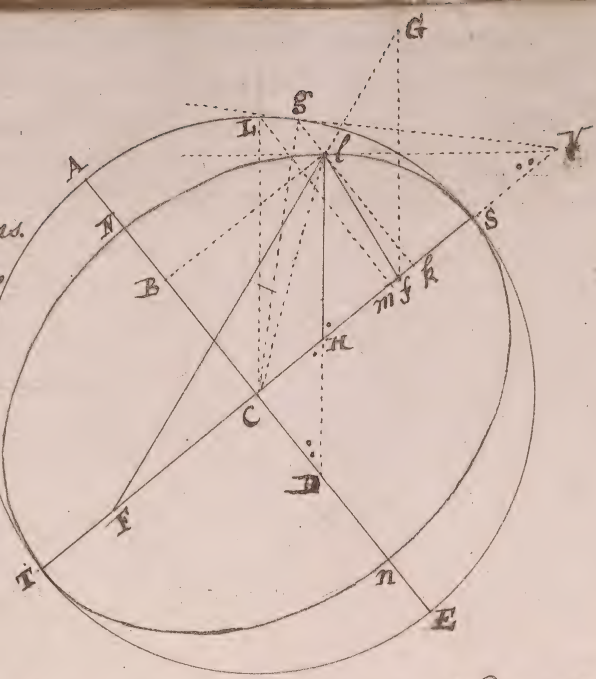
A violent fire & large Hail stones often proceed out of the same cloud.
Air increases fire, & yet the blast which animates the fire on the hearth
would extinguish the taper. The same fan equally cools & lights our fire.

April 22^d 1768. Meditation upon Fire. It appears to me that Fire exists in
3 different states and Conditions, and that Fire, Light, heat, air, darkness and Cold are
all one and the same thing. I. Fire in Orb, ~~burns~~ heats, burns & shines besides many other properties
of penetrating into other ~~matter~~ bodies, &c. II When ~~it loses~~ the ~~sm~~ most subtle & minute parts are
dissipated, & it hath proceeded so far as to lose the properties or qualities of heating, burning and shining
conjointly, I call it Fire disseminated. ~~3. When it hath proceeded yet farther & lost the~~ And this
~~& either~~ 1. retains the property of shining, either with or without heat, & is then what I would call Light.
Or, 2. it retains the property of heating, with or without shining, and this I call heat; whereby Light
and heat are only two different sensible qualities of Fire. III. When this disseminated Fire
becomes so languid as, just to lose the two last sensible qualities, I would call it Air disseminated;
2ndly this hath the property 1 or quality of darkness either with or without Cold. Or, 2. it hath the
[illegible] of Cold either with or without darkness. And when it hath obtained
[illegible] qualit[illegible] of darkness & Cold in the most intense degree, as Fire in Orb

motion. The heats of Cayene, however great, are not sufficient to
produce this phenomenon: 'Twas therefore no longer doubted, but the pressure of gravity was less at Cayene than at Paris." Page 28, 29, 30 & 31 of

The Rudiments of Geography. From the French of M. Maupertuis. London: Printed for E. Cave, at St John's Gate 1743. 12mo

I do not meet with the following proposition in books on the Conic Sections. Tho' it is useful for reducing the Latitude of a place in the Sphere to that in a Spheroid; and computing the horizontal parallax of the moon for any given latitude upon the Spheroid, from any given equatorial horizontal parallax in the sphere.



Proposition.

~~As the square of the conjugate diameter Nn, of any ellipse, is to the square of the transverse diameter TS, so is any semiordinate lk or BC, to~~ In any ellipse, the line lD drawn from the point l, to bisect the $\angle Flf$, and consequently perpendicular to the tangent lV, will intersect the ~~conj~~ conjugate diameter Nn in D; and lB being drawn parallel to the transverse TS; it will be $\overline{Nn}|^2 : \overline{TS}|^2 :: BC : BD$, or $\overline{NC}|^2 : \overline{TC}|^2 :: BC : BD$.

Analytic Demonstration.

The semitransverse TC put $= t$, $NC = c$, and $a = Ck$, the distance of any semiordinate lk, from the center C. Then $Tk = t+a$, and $kS = t-a$: by the property of the ellipse $t^2 : c^2 :: \overline{t+a} \times \overline{t-a} : \frac{\overline{t^2-a^2} \times c^2}{t^2} = \overline{lk}|^2$; and $lk = \frac{c\sqrt{t^2-a^2}}{t} = BC$.

By the property of the tangent to an ellipse, (De la Hire's Conics, Part II. Prop. 11. p. 54) $a : t :: t : \frac{t^2}{a} = CV$; and $CV - Ck = kV = \frac{t^2-a^2}{a}$. The $\angle$s Blk, HlV, being each a right $\angle$, the common $\angle Dlk$, there remains $\angle BlD = \angle klV$; whence the right angled Δs klV, BDl are similar: $\therefore \frac{c\sqrt{t^2-a^2}}{t}(lk) : \frac{t^2-a^2}{a}(Vk) :: a(Bl = Ck) : \frac{\overline{t^2-a^2} \times t}{c\sqrt{t^2-a^2}} = BD$: whence $\frac{c\sqrt{t^2-a^2}}{t} : \frac{\overline{t^2-a^2} \times t}{c\sqrt{t^2-a^2}} :: BC : BD$; which brought out of fractions is $c^2 : t^2 :: BC : BD$. Q. E. D.

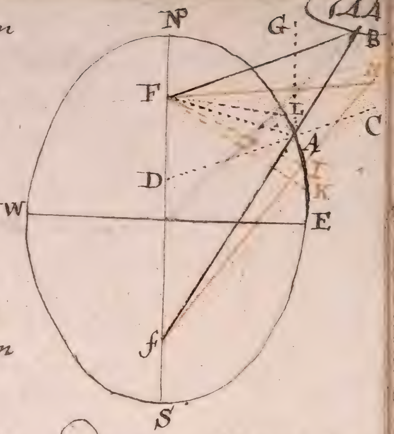
Synthetic Demonstration.

The semiordinate kl continued to intersect the circumbing circle in g, the line Vg will be a tangent to g: The Δs CgV, Cgk are similar by 8.E.6. whence $Vk : kg :: kg : Ck = \frac{\overline{kg}|^2}{Vk} = Bl$. By the same 8.E.6. the Δs Vkl, Hkl are similar; whence also, $Vk : kl = BC :: BC : Hk = \frac{\overline{BC}|^2}{Vk}$. The Δ Hkl, DBl, being right angled, are similar by 15.E.1. thence is had $\frac{\overline{BC}|^2}{Vk}(Hk) : BC(kl) :: \frac{\overline{kg}|^2}{Vk}(Bl) : BD$: $\therefore \overline{kg}|^2 = BC \times BD$. Now by the property of the ellipse $TC : NC :: kg : kl = BC$, and thence $\overline{gk}|^2 = \frac{\overline{TC}|^2 \times \overline{BC}|^2}{\overline{NC}|^2} = BC \times BD$; which gives $\overline{TC}|^2 \times BC = \overline{NC}|^2 \times BD$; and $\therefore \overline{NC}|^2 : \overline{TC}|^2 :: BC : BD$. Q. E. D.

Or thus. $Vk : kg :: kg : Ck = \frac{\overline{kg}|^2}{Vk} = Bl$, as before; the Δs Vkl, DBl being sim. $BC (= lk) :: Vk :: \frac{\overline{kg}|^2}{Vk}(Bl) : BD$; $\therefore \overline{kg}|^2 = BC \times BD$; whence as above $\overline{NC}|^2 : \overline{TC}|^2 :: BC : BD$. Q. E. D.

See p. 7. a curious Quest. on this subject.

Ellipsis divided into Degrees.



Let NPESW be an ellipsis, representing a meridian of the earth, according to M. Cassini, where NP is the north pole, S the South pole, F & f the two foci. It is supposed to revolve upon its longer axis NPS & generate a Spheroid.

Let it be required to divide this ellipsis or meridian into degrees, ~~from~~ as LA, IK, for any given latitude A, I.

From the focus F draw an indefinite line FB, making ∠NPFB = zenith distance of the given place A from the pole NP, or the Colatitude: from f make fB = NPS, then fB cuts the ellipsis in A, the proper situation of the given place upon the Spheroid.

Demonstration.

Let DAC bisect the angle FAf, then from the nature of drawing tangents to an ellipsis C will be perpendicular to the point A, & consequently its zenith. draw AG || to NPS, which is supposed to direct also to the pole, which is at an infinite distance: Then ∠GAC = NPDC = zenith distance of A from the pole. fB = NPS, by construction, = FA + fA, by property of the ellipsis; ∴, by taking away fA common, FA = BA, ∴ ∠BFA = FBA = FAD, half the external ∠FAf, ∴ FB is || to DA, and ∠NPDA = NPFB, the Colat. of A per construction. Q.E.D.

Now, by having the ratio of NPS to ~~Ff~~ Ff, we may calculate all the points of the ellipsis, as A, which terminate the degrees. For fB = NPS : Ff :: Sine ∠NPFB : Sine ∠FBf = BFA, which added to NPFB gives ∠NPFA. Now in ΔFAf, there is given Ff, ∠FAf = 2∠BFA, and ∠fFA = supplem^t. of NPFA, from whence FA may be found. In like manner ∠s NPFL, NPFI, NPFK, and the value of the lines FL, FI, FK, the distance of the pole to the zenith, of all the degrees of the circumference of the earth. In the rectilineal Δs LFA, IFK the sides LF, AF, IF, KF, and the contained ∠s LFA, IFK are known; hence the chords LA, IK, subtending one degree, may be determined. and since upon this elliptical hypothesis, the ratio of these chords do not sensibly differ from that of the arches of the ellipsis which they subtend, we have also the ratio of one degree to another in different Latitudes, provided the eccentricity be given.

For greater accuracy we might calculate the chord of 30' or 15', to make the difference of the ratio between the chord & its arch vanish: but since the arch of one degree exceeding its chord by only 4 feet (french) the difference between the chords of each degree & that of the arches is insensible themselves.

Extracted & entirely new methodized from Memoir 4. of the Royal Academy of Science at Paris for the year 1713. p. 298, 9, & 300. of Vol. 4. of Martyn's & Chamber's Abridgment.

Of the blood in the Heart.

from gents Mag. May. 1768. p. 224. by J. Cooke, of Leigh.

There is a very curious and extraordinary phenomenon attends the heart in animals, which is known but to few.

There are two coronary arteries arising from the beginning of the aorta, before it goes forth from the pericardium, which encompasses the heart; and thence take their name. They extend many little branches from the basis to the cone, of which the most and longest are conspicuous in the left side.

There are as many coronary veins which return the blood back into the vena cava, or hollow vein.

Now, what is very remarkable, the blood enters into these arteries at a time asynchronous to that in which it enters into the other arteries of the body. The direction of these arteries, with respect to the course of the blood through the aorta, or main trunk, is such as greatly impedes, if not wholly stops the transit of the blood thro' them, whilst the heart is

is in its systole, or state of contraction. This is apparent to those who in what a retrograde manner they arise, making very acute angles with that part of the aorta which is nearest the ventricle.

Besides, the muscular ~~ventricles~~ substance of the heart, to which these two arteries are distributed, is during its systole in so firm and contracted a state as is very unfavourable to the passage of the blood through it at this juncture. These are the causes that hinders the blood's entering these coronary arteries, at the same time in which it enters the rest, all over the body.

That the blood when forced out of the left ventricle into the aorta, or great artery, makes immediately, on the cessation of the impelling power, a considerable push back again, may be reasonably inferred from the known use of the semi-lunar, and several other valves belonging to the heart; and from the resistance, the sides of the arteries, and the blood with which they are replete, must necessarily make to its progressive motion.

Now if the impetus with which it recoils on the valves be sufficient to raise them, surely it must enter the coronary arteries at this time, especially as the soft relaxed state of the heart, as well as the direction of the arteries themselves, so remarkably favour such a transit; and that this is the very case any one may satisfy himself by Autopsy, on viewing a frog opened, or other small animals, when he will behold the heart become red at the beginning of each dyastole, or opening thereof, and to continue so during the whole time of its relaxed or inactive state, till the commencement of the systole, when it immediately becomes white, and continues so during the whole contraction. What greater demonstration can be required than what these two remarkable circumstances afford, both that the blood does enter these two coronary arteries during the hearts dyastole, and does not in the least during its systole, when it enters the aorta, and other arteries.

In what manner this particular contrivance of supplying the heart with its blood during the dyastole was designed to influence each succeeding systole, and other secrets belonging to the same, the great Καρδιογνωστης only knows.

Case of a lad, who fractured his skull.

Gent. Mag. May. 1768. p. 227. by J. Cooke, of Leigh. Also in the Universal Museum, Vol. III. p. 247. for 1768.

A Lad, by a fall, fractured his skull, and was trepanned. What was very surprising, the wounded side enjoyed all its functions freely, while the contrary side, unhurt, directly lost its power of motion, and became paralytick by the blow. His fingers, on the opposite side, continue contracted still, as also his ham, otherwise as to health and senses, he is as well as ever, although he has lost half his brains.

It is plain, that it proceeded from the different origin of the nerves from the opposite side in which they terminate. For which end they cross before they make their exit through the

the vertebral holes of the spine; whence those nerves which spring from the right side terminate in those parts which form the left side, and *vice versa*.

So that the right side of the body on which the brain was wounded was not affected thereby, as expected, but the opposite side, which was supplied by the nerves whose origin was from the wounded side; while the other side, supplied by nerves proceeding from the sound side, though opposite thereto, possessed its faculties as freely as if no wound at all had happened.

Thus we see observation and experience, are the two surest sources of certain knowledge; far beyond all uncertain hypothical reasonings *a priori*, however entertaining and instructing, such may be *a posteriori*.

Advertisement of a history of Barbados with a curious observation made by cutting down the Woods there.

A Short History of Barbados, from its first Discovery and Settlement to the End of the year 1767. Small 8vo 2s. 6. Dodsley.

In which are these remarkable words, quoted by the Reviewers of the Monthly Review for July 1768. p. 16. viz.

"The Destruction of the Woods in that Island, (Barbados) though it renders the Country more healthful, hath decreased the Quantity of Rain, and hath been thereby detrimental to the Planters.

To find the focal lengths of Object-glasses & Diameter of the Apertures of Telescopes.

Problem

The magnifying Power of a Refracting Telescope, the Focal length of the Object Glass, the Diameter of its Aperture, the focal length of the Eye Glass, ~~and the Diameter of its Aperture~~: any One of these being given to find all the rest.

Put $\begin{cases} a = \text{magnifying power} \\ B = \text{focal length of the Object Glass in Feet.} \\ D = \text{the diameter of the Aperture of the Object Glass in Inches.} \\ b = \text{focal length of the Eye Glass in Inches.} \\ \cancel{d = \text{the diameter of the Aperture of the Eye Glass}} \end{cases}$

Then per Rule on page 44, $\sqrt{,3B} = D$ (9,7385606½), and $1,1\sqrt{,3B} = b$ (9,7799533½);

whence $\frac{12B}{b}$, or $\frac{12B}{1,1\sqrt{,3B}} = a$; which divided and reduced, the equation becomes $19,9126\,B^{\frac12} = a$ (1,2991278½); Whence,

I. $B = \overline{,0502195\,a}^2$ (8,7008721½), or $B = ,002521995\,a^2$ (7,4017443) $= 3,33D$ (0,522878) $= 2,754814\,b^2$ (0,440[illegible]).

II. $a = 19,9126\,B^{\frac12}$ (1,2991278½) $= 36,35526D$ (1,5605672) $= 33,05023\,b$ (1,5191745).

III. $b = ,030257\,a$ (8,4808255) $= ,602495\,B^{\frac12}$ (9,7799533½) $= 1,1D$ (0,0413927).

N.B. The Red figures are the Log.ms of the Nat. No.s over them.

A computation of the powers in an Eight-Day Clock.

Put
$a = 2$ Inches $=$ Barrel & Semidiam. of the line together
$b = 3 =$ the Diameter of the 1st Wheel.
$c = 2 =$ the Diameter of the 2nd Wheel.
$d = 1,9 =$ the Diameter of the 3rd Wheel.
$e = 1,8 =$ the Diameter of the Swing Wheel.
$\alpha = \frac{3}{8} =$ the Diameter of the pinion driven by the 1st Wheel
$\beta = \frac{2}{8} =$ the Diameter of the pinion driven by the 2nd Wheel
$\gamma = \frac{1,9}{7} =$ the Diameter of the pinion driven by the 3rd Wheel

$f = 1,44 =$ The distance of each Palet from the center of its axis.
$g = 3,75 =$ The distance of the Crutch from the center of its axis.
$w = 7\frac{1}{2}$ ℔ The weight supported or acting on the barrel a.

Then by Mechanics, reciprocally,

$a : w :: b : \frac{aw}{b} = 5$ ℔ the power on the 1st Wheel or on the pinion it drives.

$\alpha : \frac{aw}{b} :: c : \frac{\alpha aw}{bc} = \frac{15}{16}$ ℔ $= ,9375$, the power on the 2d Wh. or the pinion it drives.

$\beta : \frac{\alpha aw}{bc} :: d : \frac{\alpha\beta aw}{bcd} = \frac{300}{2432}$ ℔ $= ,1234$ ℔; the power on the 3d Wh. or on the pinion Do.

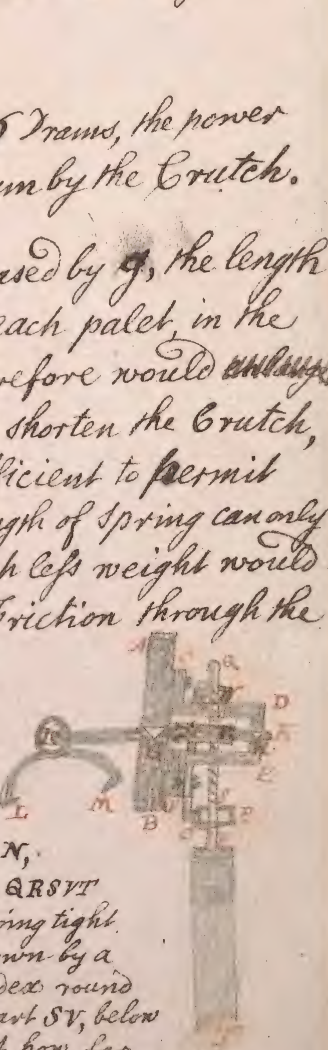
$\gamma : \frac{\alpha\beta aw}{bcd} :: e : \frac{\alpha\beta\gamma aw}{bcde} = \frac{28500}{1532160}$ ℔ $= ,018601$ ℔, the power on the swing Wheel, or on each Palet.

$f : \frac{\alpha\beta\gamma aw}{bcde} :: g : \frac{\alpha\beta\gamma awf}{bcdeg} = ,0071428$ ℔ $= 1,8286$ Drams, the power communicated to the Rod of the Pendulum by the Crutch.

In this computation the power on the swing-Wheel is supposed to act upon the pallets and drive them with all that power in a tangent to the circle which the acting point would describe round their arbor: which is not true.

Here it is evident, the weight w is decreased by g, the length of the Crutch, exceeding f, the distance of each palet, in the ratio of 3,75 to 1,44, or of 2,604 to 1.(*) I therefore would ~~enlarge the palets wheel & the distance of each palet, but~~ shorten the Crutch, till there was no more length of Spring than just sufficient to permit the pendulum to swing free; ~~how long~~ This length of Spring can only be determined by experiment: Hereby a much less weight would serve, & consequently greatly diminish the Friction through the whole Clock. Instead of the common pendulum hanging by a Spring, (which is subject to irregularities by heat & cold, dry and moisture,) I would propose, in the annexed fig. AB, part of the back plate or frame, to which the cock CDEF is screwed: At G & H is triangular holes for IK the axis or arbor of the palets L, M, to work in. To this Arbor IK, ~~which is~~ at N, ~~the~~ is fixed the Crutch NOP. That part QS of the pendulum QRSVT ~~which is~~ above the bottom of the crutch OP, is a screw, going tight through a hole at R in the axis IK, and raised or let down by a nut W bearing against the arbor IK, and carrying an index round a plate of divisions to estimate ~~the~~ the quantity. That part SV, below the crutch is circular for the crutch to work upon. But how far the friction here is greater than the power to bend the spring, experiment can only determine.

(*) if the center of suspension, from which the rod & ball of the pendulum are pendent, is fixed, no length of the crutch will alter the power.



determined. — From the above operation & this method of hanging the pendulum, it appears that the distance of the crutch from the center of its Axis may be equal to (,A) the Diameter of the Pinion driven by the third Wheel, and that of the Palets equal to the Diameter of the swing Wheel, in which case, the power communicated to the Rod of the Pendulum is equal to that acting upon the Swing wheel. and would be 2,601 Times greater in the above Clock than there found.

Upon a second view there is no necessity for any crutch NOP, since the Rod passes tight through a hole at R in the same axis, and the semidiameter of the Arbor IK, where the pendulum hangs, is to be considered as the Crutch, which may be even $\frac{1}{10}$ of an inch, and then the power upon the rod of the pendulum in the above clock, (all other circumstances remaining the same as there given) would be ,267856A.lb which is 37,3 times greater than with that crutch, so that with this crutch of $\frac{1}{10}$ of an inch, and supposing the friction in this case requires no more power than the Stiffness of the spring in the common way, ,2.lb acting upon the barrel would communicate the same power to the rod, as in the above 8 day clock.

Barometer, on the rise & fall of the Mercury therein.

In assigning the cause of the rising and falling of the mercury in the Barometers, it is generally assumed and asked, why does the quicksilver fall in the Barometers when the air air is turbid and rendered heavier by various exhalations, and rise again when the air air is rendered lighter by clearing? Whereas every thing ought to happen quite contrary. ~~The~~ In the question thus put, there is something assumed a supposed, which has never yet been proved, nor can easily be proved; viz, the air is rendered heavier, by being turbit & replete with various exhalations; and on the contrary lighter when it is clear. But the difficulties are removed by denying both these suppositions. Who can imagine that the motes in the circumabient air of a dark room were not present there before they were discovered by letting the light of the Sun, or that they retire as soon as this light is freely admitted? Let us omit the many experiments which have frequently been made with acid and alkaline salt, and select one which is more to our present purpouse.

Quantity of Vapous do not add to, or depend upon the weight of the air.

Put the glass bell over the wet orb of the pnuematic engine, and, when the air pump begins to work, some light clouds or vapours will arise in the bell, (as related in the accout of refraction, p.9.&10.) which immediately ~~disperse~~ disperse & disappear upon the admition of the air. These exhalations could not enter the bell, when they became conspicuous, by diminishing the elastic power of the air: They also existed there after they disappeared, & were hidden in the pores of the air, which again sustains them by becoming heavier & more elastic. Or, those exhalations are present before they become visible by approaching each other: nor are they annihilated, or no longer exist in the air, after they disappear by being dissipated and thereby too subtle for our sight. They begin to approach one another, when the elasticity of the air is so far diminished as not to be able to sustain them; and they again recede & cease to affect our sight, when the former gravity & elastic force of the air is restored. Whence it appears, that these two things happen at the same time, viz. a diminution of the elastic force of the air and the arising of exhalations, which ~~before hung~~ were before dispersed in, and sustained by it, but are now gradually loosed, from the air & become visible by coagulating among themselves: also The air recovers its elasticity and the vapous hanging in it are dissipated and disappear; tho' the one cannot be said to be the cause of the other: nor can the air be said to be heavier or lighter at one time than another, on the account of these exhalations.

The same happens in the air which surrounds our earth. Let its elastic force be diminished, by any means whatsoever (of which hereafter) the dispersed & suspended exhalations necessarily subside & become visible, and when by

by any means it is again restored, these vapours and clouds are dissipated and vanish. But at the time, or, for the same reason, before those subsiding vapours come in view, the mercury begins to fall in the Barometer; but yet these vapours do not contribute any thing to it's descent: When or before the vapous and clouds begin to disappear in our circum=ambient air, the mercury begins to ascend; and yet that serenity of the air is no more the cause of this ascent of the mercury, than the ascent of the mercury is the cause of that serenity. It therefore is a fallacy to refer one of those phænomena, which happen about the same time, to the other as the cause, which is done by most persons.

But to make this still more apparent. Set a glass cylinder, 3 or 4 inches diameter, open at both ends, and of a sufficient length to receive a portable Barometer, upon the orb of an air pump, covered with water and wet leather, that watery vapours may enter the contained air; when replete, put in a Barometer, closed the top exactly, and exhaust the air. As the process goes on, a mist will begin to rise in the cylinder, and the mercury also in the barometer to subside at the same time: both indeed from one and the same cause, but neither the cause of the other. Admit the air again into the glass cylinder, and both the serenity of the included air will immediately ensue, and the mercury in the barometer will ascend at the same time or a little before: and yet it is evident that neither depends on the other; nay, it is manifest that it is not rendered heavier in one case or lighter in the other. Thus art in some measure imitates nature; but because of the wonderful complication of natural causes it can=not be complete, if sufficiently exact.

Causes of the Alterations of the weight or pressure of the air to be still considered.

Hence a commonly received opinion and a great obstacle is removed, yet the whole of business is not brought to a conclusion. For it still remains to know by what causes these alterations of the air are produced. — "The causes which shew how easily "the air is expanded and rarified by any approaching "heat, and particularly how great is the force of the "sun-beams falling perpendicularly, will shew, or "perhaps this alone will seem sufficient, how the "equilibrium of the air is taken away, if there were

no

"no others, which are however various. We will pass over the "diurnal revolution of the earth, and our air with it, about it's "axis; and also the annual motion of them about the sun; we "will not mention the many burning mountains on the sur=
"face of our earth, nor the many thunderings and lightnings "in the air; nor the many earth-quakes and subterraneous "fires, which so terribly shake the surface of the earth and "sea, tho' each of them may have a wonderful effect in "increasing or diminishing the elastic force of the air: and "shall at present only consider one thing, which seems "more worthy to be mentioned than the rest." Granting

"That the elastic force of the air which immediately "touches the surface of our earth, depends chiefly on the "weight of the incumbent air." Also, "That the lower air is "is more or less elastic according to the greater or less height "of the incumbent column of air, by the different heights "of the barometrical mercury, on mountains of greater "or less height, and in lower places of the earth."

Philos. Trans. N.o 492. p. 101. for 1749. Or Vol. 10 of Martyn's Abridgm.t p. 428. by Sam. Christian Hollman, Philos. Prof. Pub. Ord. Gotting. Who proceeds with this essay & shews how these alterations of the air arising from the moon's effect of raising it into tides, or longer & shorter columns, in the manner she doth the water in the seas; but it is with so little evidence or satisfaction to me, that I do not taken any farther notice of it. N.B. what is without the marks of quotation was greatly abridged from his essay, & mostly expressed in my own words.

A Philosophical Definition of Action and Effect.

"There seems to be no other difference between action "and effect, than that action, (if I may so speak) is an effect "in fieri, and effect an absolute action, or one that is perfected. "For example, a Vis viva is that which transfers a moveable "thro' a space; therefore the action of a vis viva is the "translation of a moveable thro' a space; and the effect of "a vis viva is also the translation of a moveable thro' a "space; or rather, an effect is a moveable already trans= "ferred thro' the same space.

"But generally, an action is the preceder of an effect; or "rather an action is that by which any thing is effected, but "an effect is the thing itself which is effected." Again,

"If I write a page, my action will be the writing of a page,

and

"and the effect will be a page written. — If a Workman whites "a wall, his action will be the whitening a wall, and the effect "will be a wall whitened — If a labourer digs a garden, his "action is the digging of a garden; and the effect is a garden "digged." Philos. Trans. N° 479. p. 103. 1746. by James Jurin. M.D. F.R.S. or Vol. 10. p. 193. of Martyn's Abridgm.t — At N° 9. of the Difference of Works, Vol. 1. is a distinction between action, and an act.

Expansion & Contraction of several Substances. see p. 4. 92, 140, 157.

Collected from Martyn's Abridgm.t of Philos. Trans. Vol X. from 1744 to 1750 both inclusive.

"Iron becomes $\frac{1}{60}$ longer when red-hot, than when of its "natural temperature; and D.r Derham, in his last "paper read before the Royal Society concerning the vib= "ration of pendulums, says, that a rod 39,126 inches "long, become $\frac{1}{10}$ inch longer than in its natural ~~state~~ "dimentions in temperate air, by being exposed to heat "equal to that of an human body; ,02 inch longer in hot "sunshine; that it was ,2 or $\frac{1}{5}$ inch longer than its "natural state, by being heated in a flaming heat; that "it became ,07 shorter than its natural length by being "quenched in cold water; and still ,03 shorter, by being "put into a mixture of salt & snow. From which "experiments one may conclude, that from Fahrenheit's "cold of 40 below 0. to the greatest heat iron can bear "without melting, a rod of 3 feet long will have about "$\frac{1}{4}$ inch increase." p. 440.

The Rev.d Stephen Hales, D.D. says, "A rod of iron 3 feet long will have about $\frac{1}{4}$ increase, or $\frac{1}{144}$ part." p. 446.

"A rod of brass, according to D.r Musschenbroeck's "experiments, l. c. was found to lengthen 377, when one "of iron lengthened only 230 parts." p. 443.

230 : 60 :: 377 : 98 instead of 95, on p. 92. by J. Ellicott

The said D.r Hales, says, "I have found that "wood does not contract or dilate length ways with "heat or cold. I am told that M.r G. Graham is "about making this experiment, as I am also, in "order to regulate pendulums." p. 446.

Bertoud found, that a metallic rod of 461 lines in length, at the Zero of Reaumur's thermometer, was lengthened at 127 degrees; anneal=ed steel $\frac{69}{360}$ of a line; cold hammered steel $\frac{174}{360}$; annealed iron $\frac{72}{360}$. Hardened steel $\frac{77}{360}$. Hammered iron $\frac{78}{360}$. Annealed gold $\frac{82}{360}$, gold wire $\frac{94}{360}$, copper $\frac{107}{360}$, silver wire $\frac{119}{360}$, brass $\frac{121}{360}$, tin $\frac{160}{360}$, lead $\frac{193}{360}$, glass $\frac{62}{360}$. Gent.s Mag. Vol. XVIII. p. 111. Ash expands least 1 part in 31. and the wild pine most 1 part in 19. by excessive heat and cold.

The same liquor requires different degrees of heat to boil it at different heights of the Barometer.

"The ingenious inventor of quicksilver Thermometers
"Mr. Fahrenheit hath discovered, that when the Barometer marks a
"greater pressure of the ~~sphere~~ atmosphere, the same liquor will
"receive 8 or 9° more of heat to boil it than when the Barometer is at the
"lowest." ———

Liquids do not freeze in the same order as they boil by heat.

"These, and all other liquids, by a certain determinate
"degree of cold peculiar to each sort, lose their fluidity, and
"freeze, or become solid, but not in the same order as by
"heat they boil; for by cold, oil or water is sooner frozen
"than Spirit of wine, tho' spirit of wine will boil sooner
"than oil or water. All solid bodies likewise, as minerals,
"metals, and even stones, will become fluid, or melt, at a
"certain degree of heat peculiar to each species; and, when
"thoroughly melted, it is probable they are capable of receiving
"no higher degree of heat; and, on the absence of that heat to
"a certain degree, they all return to their natural solid
"state." p. 436.

How Fahrenheit graduated his Thermometer.

"Fahrenheit begins the scale of his Thermometer from 0.
"the point to which the mercury hath been observed to fall by
"the greatest cold in Ysland; and computes, that the mercury
"then occupies 11124 parts. This is his point of no heat. Then
"reckoning upwards from this, he finds that when the
"mercury is rarified only 32 parts or degrees more, com=
"mon water just begins to freeze: in temperate air it
"will rise to 55." &c. p. 439.

Heat requisite to boil several liquids, and to melt several Metals.

Alcohol, or highest rectified Spirit of Wine, boils at	174°.	p. 439
Strongest Sunshine about	80.	p. 444.
Spirit of Wine boils at	176.	D°
▽ Water at	212.	D°
The lixivium of Salt of Tartar at	240.	D°
Spirit of nitre at	242.	D°
Oil of Vitriol at	546	D°
☿ Quicksilver at	600	D°
♃ Tin melts at (the easiest of all metals to melt.)	408	D°
♄ Lead at	540	D°
Ol. vap. ebull. Oil boils violently at	714	D°
Reg. ♁ (I suppose) Regulus of Antimony at	810	D°
☽ Silver melts at about	1000	D°
☉ Gold at about	1250	D°
♀ ~~[illegible]~~ Copper at about	1420	D°
♂ Iron, (the most difficult of all metals to melt) at	1590	D°

Mr. Harrison, in the principles of his time-keep. p. 31. Says, One part of pewter & 12 of lead melt at 567 degrees of Fahrenheit's Scale, Therefore

Pewter melts at — — — — — — — — 891.

Expansion & Contraction of several sorts of Metal.
see p. 92, 140. 155.

A Table of the expansions of Metals, shewing how much a foot in length of each grows longer by an increase of heat corresponding to 180 Degrees of Fahrenheit's Thermometer, or to the difference between freezing and boiling water, expressed in decimal parts of an inch. by Mr John Smeaton. Gents Mag. Sept. 1755. p. 401. where is a description of his Pyrometer. also Philos. Trans. Part. II. Vol. XLVIII. for 1755. Article 79.

			Specific grav.y water = 1,000
1. White glass barometer tube	,01	Glass very clear	3,650
2. Martial regulus of Antimony	,013		7,500
3. Blistord Steel	,0138	Soft steel	7,738
4. Hard steel	,0147		7,850
5. Iron	,0151		7,644
6. Bismuth	,0167		9,700
7. Copper hammer'd	,0204.	Copper not hamm'd	9,000
8. Copper, 8 parts mix'd with one of tin	,0218		8,813
9. Cast brass	,0225		8,100
10. Brass 16 parts, with tin 1	,0229	Red is computed from their simples	8,054
11. Brass wire	,0232	Fine brass	8. 350.
12. Speculum metal	,0232.		
13. Spelter solder, viz lead 2 parts, zink one	,0247		9,927
zink one	,0274		7,471
14. Fine pewter	,0298		7,320
15. Grain tin	,0298		
16. Soft solder, viz lead 2 parts, tin one	,0301		10,000
17. Zink, 8 parts, with tin 1, a little hammer'd	,0323		7,124
18. Lead	,0344		11,340
19. Zink or spelter	,0353		7,100
20. Zink hammered half an inch per foot	,0373		7,100

A Sketch of the first Principles of an Engine to turn Squares

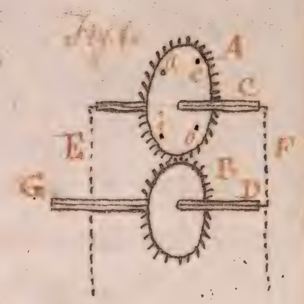


Fig. 1. AB represents two equally sized wheels, with an equal number of teeth, fixed on their axis's, C and GD running in the pieces EF; the top wheel is divided into four equal divisions, in which are fixed four pins, as aeio, at the end of the axis GD; at G is a square hole to put a mandrill in, on which is fixed the wood. In the 2nd fig. you have the wheel A with its four pins to lift the leaver cdf, running on the center c, and with its end f moving the tool with its handle H, in order to cut the square wxyz. The figure, as well as the principles, are so plain that I shall say no more to describe it, very little consideration being necessary to make the whole scheme plain and easy. After the same manner, a triangle may be turned, if the circle be divided into three parts, and from the same principles medals, faces, &c. J. B. N. (Gents Mag. Vol. 22. for June 1752. p. 271.)

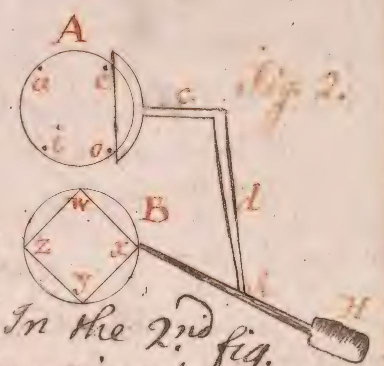


Fig. 3. ASB is a convex block, on which the glasses a, e, i, o, are fixed by cement, with their edges contiguous and level with each other; the block turns on its center by the spindle C, while the concave tool DFE, is pressed on the glasses, and grinds off their edges gradually towards the middle of each, till they are formed to the same circle of convexity, as the tool is concave.

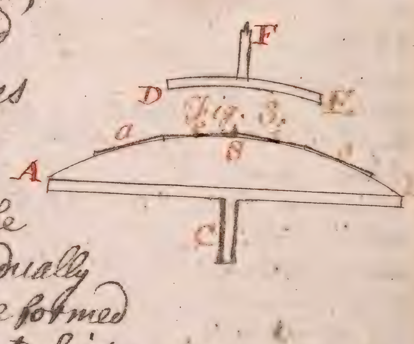
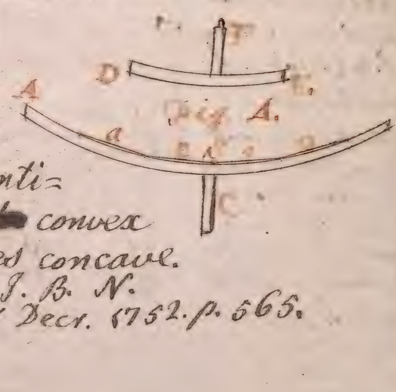
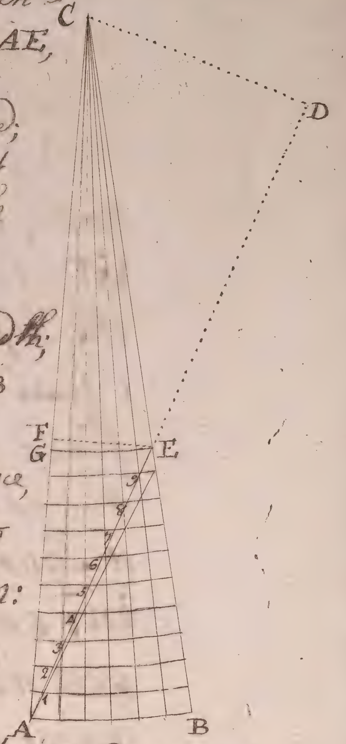


Fig. 4. ABS is a concave block which turns upon the spindle C, with the glasses fixed by cement in the concavity as at a, e, i, o, with their edges contiguous & even with each other, while the convex tool DFE, grinds the middle of the glasses concave. J. B. N.



Abbreviated from Gents Mag. Vol. 22. for Decr. 1752. p. 565.

The Subject of a Quadrant being divided by Diagonal lines & equidistant concentric circles farther prosecuted. See p. 41, 43.



Let C be the center of a quadrant, AB so much of the limb as is divided diagonally by the line AE, and ~~the~~ equidistant concentric arches. Now

1. To find the error of a quadrant so divided; continue the diagonal AE indefinitely, from C let fall the perpendicular CD, & from E let fall the perpendicular EF. Put $R = AC$, the Radius of the quadrant; $r = GC$, the Rad. exclusive of the breadth of the limb; $d = R - r = GA$, the said breadth; s & v, the sine & versed sine of the given ∠ACB to Rad. of Tables. Then p Trig. $sr = FE$ and $rv = FG$, to which add d, gives $rv + d = AF$; whence, $rv + d : \text{Rad.} :: rs : \dfrac{rs}{rv+d} = \text{Tang}^t \angle FAE$, whose ~~secant~~ sine put $= m$; then, Rad : $R (= AC) :: m : Rm = CD$. let n be the number of concentric circles, with $=in$ the space AG or BE the breadth of the limb; then, ~~the distance of the first~~ $\dfrac{d}{n}, \dfrac{2d}{2n}, \dfrac{3d}{3n}$, &c. = distance of the 1st 2d 3rd &c. from A. Now in Δ ACD, ∠ACD = compl. of the ∠CAD, found above; & supposing C1 drawn (for these several Radii should have passed thro' the intersection of the diagonal AE and their respective concentric circles) which is $= R - \dfrac{d}{n}$; thence p Trig. $Rm : \text{Rad.} :: \dfrac{Rn-d}{n} : \dfrac{Rn-d}{Rmn} = \text{Secant} \angle 1CD$, which subtracted from ACD, gives the quantity of the first concentric circle. $Rm : \text{Rad} :: \dfrac{Rn-2d}{n} : \dfrac{Rn-2d}{Rmn} = \text{Sec.} \angle 2CD$, which taken from ACD, remains the quantity of the second concentric circle; and so on for the rest.

2. To find the true distance of the concentric circles. The arch AB in degrees, minutes, &c. divided by n, will give the quantity of each respective circle, from the next. or $\dfrac{AB}{n}, \dfrac{2AB}{n}, \dfrac{3AB}{n}$ = quantity of the 1st 2d 3d &c. from AB respectively; to find the Radius of which, the ∠CAD and CD, must be had as above; then to ∠CAD, add the quantity of the 1st 2d 3d &c. ~~from AB~~, concentric circle from AB, which gives ∠C1D, C2D, C3D, &c. the sine of which call p; then p Trig. $p : Rm (= CD) :: \text{Rad.} : C1, C2, C3$, &c. the Radius of each respective circle.

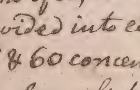
Supposing the Rad. of the quadrant = 72 Inches, = AC; breadth of the limb AG = 6 Inches, and AB to contain 5', which is subdivided into 5" by 60 concentric circles; I have, by the method above, calculated the quantity of every 5th circle from AB, as under.

Rad. of each circle.	con. Cir.	Should be from AB.	But is by Calculation.	Error too much
72 for	1st	0.00"	0.00"	0"
71½ for	5th	0.25	0.21,9	3,1
71	10th	0.50	0.44,2	5,8
70½	15th	1.15	1.06,9	8,1
70	20th	1.40	1.29,8	10,2
69½	25th	2.5	1.53,1	11,9
69	30th	2.30	2.16,7	13,3
68½	35th	2.55	2.40,8	14,2
68	40th	3.20	3.05	15
67½	45th	3.45	3.29,6	15,4
67	50th	4.10	3.54,7	15,3
66½	55th	4.35	4.20,1	14,9
66	60th	5.00	4.45,9	14,1

(*) Or thus

$\dfrac{Rn-d}{n} (= C1) : \text{Rad.} :: Rm (= CD) : \dfrac{Rmn}{Rn-d} = S. \angle CD$. or $S. \angle C1D$, whose Compl. is 1CD.

Mr Jones's Quadrant to the best of my remembrance was 5 feet 10 Inches from the center to the exterior circle of the limb, had 30 concentric circles about ,15 Inch distant from each other, and each upon the diagonal line was 5 seconds of a degree: from whence the limb of the quadrant or the whole angular extent of one Diagonal line reaching from the exterior to the interior concentric circle was 2½ Minutes; which gives only ,051 Inch for the length of the arc between each division on the exterior limb; whereas I think it was not much less than $\frac{1}{10}$ Inch. And if so, it was divided into every 5" & 60 concentric circles. which I take to be the case upon farther consideration & that the breadth of the limb was about 4 or 5 Inches. — I think each 5" was about this measure, viz.



Air, and not heat, the principal cause of evaporation.
See II. p. 105.

Hugh Hamilton D.D. F.R.S. Professor of Philosophy in the University of Doublin, in his 2d Edit. of his Philosophical Essays, 12mo 2s. 6d. 1769. has the following. ~~experiment~~

It is generally allowed that heat or fire keeps bodies fluid, by causing their particles to repel each other; and he shews that all degrees of heat, above that which is necessary to keep them fluid will separate from their surface (except mercury and those which are viscid) some kind of vapour or steam, which for the sake of distin~~ction~~guishing it from that raised by the solvent power of the air, he calls an effluvium. As this effluvium visibly rises in great abundance from hot liquors, when ever the pressure of the atmosphere is taken off, he thinks there is reason to suppose that it will rise more copiously from colder liquors, under the same circumstance, and to prove it he brings this experiment. Having placed four equal quantities of spirits of wine, in a large room without a fire, where they remained 21 hours; the first under a receiver full of air: the second, under one only half full of air: the third, in air rarified 12 times: and the fourth, in open air, he found that the spirit, inclosed in the receiver full of ~~air~~ confined air, had lost a quantity expressed by the number 1; that the spirit, inclosed in air rarified one half, had lost $1\frac{5}{17}$ such parts; that in air rarified 12 times 6 parts; and that in the open air, 18 parts. ~~Hence~~ Hence it appears, that the last-mentioned quantity, or that lost by common evaporation, in the open air, was eight times greater than that lost by ~~mere~~ the mere operation of heat, or the effluviam raised by it alone, in air rarified 12 times; & he thence infers that the cause of common evaporation must be a much more powerful one than that which raised the effluvium in the exhausted receiver. It appears farther, that the quantity, lost by evaporation in the open air, was 18 times greater than that which was lost, ~~by~~ in the same time, by the effluvium raised by heat, in the receiver full of air; so that supposing the same quantity of effluvium to have risen in both cases, the loss only of one part in 18 can be attributed to the mere operation of heat, and that consequently the other 17 parts must have been carried off from the fluid by some very powerful action of the air, at large, who

whose particles likewise being in continual motion, successively attract, dissolve, and carry off, those on the surface of the fluid: while the ~~sam~~ small quantity of air contained in the receiver, lying at rest over its surface, dissolves only an almost imperceptible part of it: the small quantity lost being, in this case, almost solely affected of heat. — Further, it appears that ice, or water which has no more heat than is necessary to keep it fluid, evaporate sensibly in the open air; while they sustain no sensible loss, under the same degree of cold in vacuo; and that therefore heat can be considered only as accessory to evaporation, which it promotes by repelling the particles of fluids from the surface, and from each other, whereby they are attenuated, their surface is increased, and the air thereby enabled, as happens in other solutions, more speedily to dissolve and keep them suspended. So that tho' the action of the air on water and other fluids is not the sole, yet it is the principal cause of evaporation: for though the particles of water are driven from its surface by the repelling power given them by heat, yet it is principally by the attraction between water and air that they are raised from the surface, and by the same continued action remain suspended. — Thus far Dr Hamilton, according to the Monthly review, for May 1769. p. 394.

Objected to.

I am inclined these experiments were not made with due circumspection, and that many material circumstances are not taken into the account, as no notice is taken of a proportional quantity of air containing also a proportional quantity of light & heat, but all is suppose to be air; certainly the free access of air to the open quantity of Spirits of wine, brought with it also a free and continual current of heat along with it. — His account of these experiments is contrary to the clearer experiment on p. 152. wherein appeared the most vapor with the less air, and less vapour or exhalation with more air. — I cannot think his state of the case for evaporation will hold, any more than his old adopted powers of repulsion & attraction.

On the transparency of a luminous object through a luminous medium; as Electric matter, Aurora Borealis &c.

The said reviews p. 397. in their account of this author's opinion about the tails of Comets, and speaking of the similarity between some of their effects and those in electricity; they say, "To the instances of this resemblance, the authors has given, he might have added the very similar effects ~~of~~ which the electric matter and the Aurora Borealis produce upon the magnetical needle: the

the former, in giving polarity to it, or reversing that which it had already acquired, the latter in very sensibly disturbing its direction. We have observed likewise another point of resemblance between them, which has not been noticed by the author, nor, we believe, by other writers: we mean the transparency of the electric fluid, evinced by the facility with which a small luminous body is seen through a stream of electric matter in vacuo, notwithstanding the seeming opacity of the latter. The small speck of light, for instance, remaining on the tip of a very small wax taper, after the flame is extinguished, (and which in some kinds will continue burning a considerable time) is as distinctly perceived through a dense luminous ~~col~~ column of electric light, passing from the wire of a charged vial, and flowing through the vacuum in the upper part of a barometer of a large bore, as when it is viewed through the tube, when the electric light no longer passes through it; and does not ill represent a fixed star seen either through the Aurora Borealis or the tail of a comet. The light proceeding from a small piece of Phosphorus, though more lasting, is not so well adapted to this experiment; as being of the same colour with the electric light, and accordingly not easily to be distinguished from it."

An Objection. This experiment, at best, is very precarious, for our senses are not capable of judging of the transparency of the medium, and the brilliancy of ~~the~~ a luminous object seen thro' it, is so nice a case. But I am certain from my own experience, it is not true in the matter of fact which it is brought to illustrate; for a fixed star seen thro' a strong Aurora Borealis is never so bright as when there is none. It is well know that mists, exhalations, &c. obstruct the brilliancy of luminuous objects, and if one medium has this effect, why not another. — This experiment of the Reviewers, if true, confirms Jones's opinion about sound not being obstructed by Winds, &c. and the easy penetrability of one fluid through another, at p. 271&c. of his Essay on the first principles of natural philosophy.

A New Equation of Time.
Gent. Mag. p. 8-12 for 1738.

Of a certain Astronomical Equation, either unknown or neglected by Astronomers, without which the Calculation of the Longitude, by Eclipses of fixed Stars by the Moon, is necessarily subject to unavoidable Errors, which may amount to some Degrees of Longitude.

Tho' every Objection made against a plain Demonstration must fall of course, and upon that account may deserve no Answer, yet I could not be satisfied, till, by the Permission of God, I had found a proper and mathematical Answer, to every rational Objection, that may be made against my Theory concerning the Parallax of the Sun.

2. The most important Objection, or at least that which I found the hardest for me to solve, is this:

Objection to it.

That the common Construction or Projection of Solar Eclipses, as it is explained by Sir Jonas More, answers exactly the Phenomena, tho' the Parallax of the Sun in reference to the Globe of the Earth be wholly neglected, or supposed only of 10″ Seconds. But that if it be supposed, by a Medium, that the Sun's Parallax in reference to the Orbit of the Moon be of about 2° Degrees 28′ Minutes, it is not conceivable that the said Projection could answer equally, and so nicely, the Phenomena.

Atmosphere of The Moon.

3. Having long considered this Objection, I concluded at last, That the true Answer to it must arise from the sensible Refraction of Light, when, in its Passage thro' the Atmosphere of the Moon, it touches almost the Surface of the Moon.

Observed, in Eclipses.

4. For that Atmosphere having been seen visibly, to about the Altitude of a Digit round about the Moon, in the total Eclipse of the Sun, in 1706 (as it did afterwards in 1715) I concluded that there is such a Refraction: And I found then a Method

how

how to determine it, by the four ~~the four~~ apparent Contacts of the Sun and of the Moon, or at least by some of them.

Moon's Atmosphere Refracts the light.

5. And, that there is a sensible Refraction of Light in the Moon's Atmosphere, is evident to me, from an Observation which I made in the Royal Observatory at Paris, above fifty years ago. For I observed there, with a Telescope of about twenty Feet, an Occultation of a considerable Star by the Moon, when, to my great Surprize, the Star seemed to touch the Moon, for a very considerable Time, before it disappeared. And I suppose that many other Persons have had, or will have, frequent Occasions of making the like Observations.

6. And indeed, altho' that Atmosphere, in which we can observe no Clouds, were ever so thin and pure; yet its Refraction must needs be supposed very sensible, since, in our terrestrial Atmosphere, the Horizontal Refraction of Light amounts to about 34 Minutes.

Light from the Sun strongest on the Moon in Solar Eclipses

7. Add to this, that altho' the mean Degree of Light and Heat, which the Sun spreads upon the Surfaces of the Moon and of the Earth, be almost the same thro' the whole Year: Yet the Light of the Sun which shines upon the Surface of the Moon, at the Time of a Solar Eclipse, is considerably stronger.

Case of a Ray Refracted at a planet.

8. If an Horizontal Ray of Light were so refracted near any Planet, as to have the Center of its Curvature in the Center of the Globe itself, it would move round the Globe, in a concentric Circle, as long as the Globe's Atmosphere might not alter the Swiftness of that Ray of Light.

Another case of D°

9. But an horizontal Ray of Light that has its Passage free, sinks all along under its own Horizon, and describes, within the Atmosphere, a Line of an hyperbolical Kind. Whereas, in that Part of its Way, in which the Refraction can have no sensible Effect, it describes two Lines that are sensibly Straight. And their Inclination to one another is

mea:

measured by an Angle which is equal to twice the horizontal Refraction. And so, in our Atmosphere, that Angle amounts to about 1° 8′ or 178°. 52′.

Effects of an horizontal Refr.n in our Atmosphere, considered.

10. In order then that we may the better argue concerning the Refraction of Light in the Atmosphere of the Moon, let us consider, in this Discourse, the Effects of the horizontal Refraction of Light in our Atmosphere. For these Effects, which depend partly upon the Height at which our Atmosphere ceases to refract the Rays of Light, would appear very singular and curious, if the Eclipses of the Sun, or of fixed Stars, by the Interposition of the Earth, were observed, for Instance, from the Globe of the Moon. And the like may be said of the Refraction of Light in other Planets also.

Height of the Atmosphere. Sir I. Newton neglected the great cold in the upper reigons in considering Refraction, for which no Tables can serve universally.

11. That Height is by Sir Isaac Newton, p. 463. made of 35 or 40 Miles. For he calculated with great Pains, upon a physical Hypothesis, a Table of the Refractions of Light, from the Zenith to the Horizon. In the making of which I suspect he took no sufficient Notice of the Condensation of our Air, by the the great Coldness which reigns in its upper Regions: whose Effect is so great, that no such Table can serve universally.

An increase in the Height of our Atmosphere, increases the apparent semidiameter of the Earth; but this does not remove the Object.n in No. 2.

~~Plate~~ Fig. 13.

12. It is true that the higher we suppose our refracting Atmosphere to be, the greater is the Number of Feet ~~which~~ which must be added to the real Semidiameter of the Earth, as seen from any Distance whatsoever. But that Addition to make up the apparent Semidiameter of the Earth is very inconsiderable. For I find that if the Height (FX or FX) of our refracting Atmosphere, be of 35 or 40 Miles (as Sir Isaac Newton does suppose) the Addition (QP or Qp) to the Semidiameter of the Earth, to make up her

her apparent Semidiameter is but of 13397 Feet, or of 14367 Feet: Which, at the Distance of 64 Semidiameters from her Center, subtend an Additional Angle of 35'', 17''', 775, or of 38'', 35''', 616. But this can afford no sufficient Answer to the Objection mentioned N° 2. And knowing already the Parallax of the Sun, we must have our Recourse to the Refraction in the Atmosphere of the Moon, or to the Distance of the Moon from the Earth; or to a Complication of these two Causes at once.

A necessity of increasing ☉'s Parallax, or the Refraction of ☽'s Atmosphere.

13. The Distance of the Moon from the Earth is certainly greater than Sir Is. Newton took it to be. And so much the more we suppose it increased, so much the more, _cæteris paribus_, must we diminish the Breadth of the Shadow which Sir Isaac wants to increase, that it may answer the Phenomena in Lunar Eclipses. Therefore increasing the Distance of the Moon will not account for the Phenomena: But, on the contrary, so much the greater will be the Necessity of having Recourse to the Increase of the Sun's Parallax. And the Consequence of this will be a Necessity of a proper Refraction in the Atmosphere of the Moon, that we may account for the Phenomena in Solar Eclipses, or for the Proportion of 100 to 365, which Sir Isaac Newton gives to the Diameters of the Moon and of the Earth, and to which Proportion the Projections for Solar Eclipses being fitted duly, they will then answer nearly to the Phenomena. And by this means the Measure itself of the Refraction of Light in the Atmosphere of the Moon will be found, since I have found the Sun's Parallax already.

To measure the Refraction of ☽'s Atmosphere.

But

But that Refraction may be found also immediately or directly, by the Length or Duration of the sensibly close Contact of a fixed Star, &c. with the apparent Limb or Disc of the Moon.

A method to find the difference of Refractions in Summer & Winder, or at different Elevations or in different Climates is practicable.

14. And since Observators may live in various Climates, and at different Heights above the Level of the Sea, and the Refractions in our Atmosphere may be different in Summer and in Winter, I contrived a Method how to find those Refractions, not by an Hypothesis, but by actual Observations. These Observations would be very useful, at least for Astronomers living in Royal Observatories, where, I should think, nothing ought to be neglected, that can contribute towards making their Observations accurate.

Fig. 43.

Previous considerations to determine the diameters of ☉, ☽, & ⊖.

15. Let C be the Center of the Earth OQFNO, ON her Diameter, and OXH or OxH a Ray of Light horizontal in the Point O, and prolonged in infinitum on each Side of O. Let OX or Ox be the Curve described by the Ray, as long as its Curvature is of the least Consideration. And let XH or xH Tangent of the Curve OX or Ox be sensibly rectilinear. And thus the right Line OXx will make with the Horizon of the Point O an Angle of 17 Minutes, equal to half the Refraction of an horizontal Ray in our Atmosphere. And let the Line CQP cut at right Angles HX and Hx in P and p, and the Circle OQFN in Q.

16. Taking then for Radius CP, let us conceive about the Center C the Circle PoVBAD GYNygdabvP. And this Circle will give the Apparent Disc of the Earth as increased by the Refraction. And let us consider the Earth as

unmovable, while some Stars, or the Sun, or the Moon, or some other Planet, or a Comet, may seem to pass behind the Earth: Any one of their visible Points describing its proper Curve BKkB, or DKkD, or Dd, or Gg, or AECIa, &c.

17. In all the Space which is without the Cone formed by the infinite Tangent HL or Hl (of the refracting Atmosphere) and having H for Vertex, and HC for Axis, the heavenly Motions observed from the Point H will seem the very same, and to have the same Swiftness, as if the Earth had no Atmosphere.

18. And whereas, because of the Interposition of the Earth, no Lucid Point in the Heavens, contained within the Circle whose Radius is CP or Cp, can be seen directly from H, but only by the Refraction made in our Atmosphere: Therefore no such Points whatsoever, were it even a Part of the Surface of the Sun, can appear within the Apparent Limb of the Earth, but only upon or near this very Limb, and that with a very small Breadth or Thickness.

19. Thus from whatsoever Place, called here H, the Globe of the Earth be seen, as suppose from the fixed Stars, or from the Moon, or from the Sun, or from Venus, or Mars, or from a Comet, &c. it may be said;

As the Distance CH, Is to the Semediameter CQ of the Globe of the Earth: So is the Radius of the Tables, To the Sine of the mathematical Apparent Semidiameter of the Earth as seen from the Point H.

And as CH, Is to CP or Cp perpendicular to HX or Hx: So is the Radius of the Tables, To the Sine of

of the visible Semediameter of the Earth, as increased by the Effect of the Refraction; or by the Distance of the Point P (or p from Q or from the Surface of the Earth.

20. Let the right Line AECIa be perpendicular to the Diameter oCN. And let the Arc AI or Ea in the heavenly Sphere subtend an Angle of i ∂, in reference to an Eye placed at the Distance CH over-against C perpendicularly to the Plan of this Figure; that is, an Angle equal to twice the Refraction of Light in our Atmosphere. And upon the Diameter EI conceive the Circle EKkI whose Center is C. And I say that if a fixed Star should be supposed to describe behind the Earth consider'd as unmovable the right Line AECIa, it will appear almost as unmovable near the Point A, seeming to slacken its Course gradually there, till the Star itself, in about two Hours Time, has reached the Point I: And then, and not before, it will disappear in A.

21. But as soon as the Star comes to the Point E, its Image will appear suddenly in the opposite Point A, upon the Circumference of the apparent Disc of the Earth: From whence or the neighbouring Points it will not depart, till the Star itself has actually reached the same Point A, Whereabout having seemed to continue all the while that the Line ECIaLz is describing, that is for about two Hours, the Star itself coming at last to Z or z will then go on full speed and pursue its Course.

22. And so, all the while that the Star, or any other the like Lucid Point, as seen from the erected Point H, describes the Line EI, the Star will appear almost unmovable near A

and A. But the Arc zA and ZA, or AZ and AZ, would be described, in an open Skie, in about 70 or 61 Seconds.

23. But if a Star seen from the erected Point H, or from the Moon, &c. describes behind the Earth, on the Side where N lies, the Curve Dd, which does not reach the Circle whose Diameter is EI; Then conceive continually a right Line passing thro' C and thro' the Center of the Star. And that Line will continually give, very near the Circumference of the Disc oANaP, the Point where the Star appears: Which, by consequence, will not be eclipsed at all: But will all the while seem to slide along near the apparent Limb of the Earth, and to describe a Curve close by the Arc DNd. And the like must be understood, if that Curve was situated on the Side of o.

24. And thus, if the Star describes a Curve BK kB or DKkD, passing at a Distance from C smaller than 8' Minutes; Then, an indefinite Line, drawn from C thro' the Star, or thro' any other the like Lucid Point, will always shew, near the Circle oANaP, the apparent Place, or the two opposite apparent Places of the Star, &c. in reference to the erected Point H, by reason of the Refraction in our Atmosphere. And all that while, the Star being in a right Line drawn from C to the Circumference, will seem to slide along very near to the apparent Limb of the Earth, and even, for some critical Moments, or Circumstances, in a retrograde Manner, as when a right Line drawn from C to D cuts the Curve DK. And as soon as the Star comes to K, or to the right Line YKCv, at about 8' Minutes from the Center of the Earth, then

the

the Star will begin to appear also in the Opposite Point v, where it will seem to touch the apparent Disc of the Earth. And from thence it will seem to move (and that very near the Limb of the Earth) from v to V, in a retrograde Manner, and to disappear in V placed upon the Limb and the right Line KCV, as soon as the Star itself reaches the Point K. And so the Star, or any other chosen Lucid Points in the Heavenly Sphere, as suppose a Point chosen in a certain Segment of the Sun, will appear at once near the Limb of the Earth in two different and diametrically opposite Places, while it really describes the Curve Kk, but seems to describe, near the Circumference of the apparent Disc, two Curves YY and vV. Which must needs afford a very singular and curious Sight.

Diameters ☉, ☽, and Hor. Refr. necessary in Projection of Eclipses.

25. Therefore this being premised, we must, in order to make a regular Projection (to represent the Eclipses of the Sun and of fixed Stars by the Moon) establish first the exact Proportion between the Diameters of the Earth and of the Moon: And at the same time find the Quantity of the horizontal Refraction of Light in her Atmosphere. These two Things I have actually done, or found out Methods to do them from Observations, and from the true Knowledge of the Sun's Parallax. Whereby not only the Errors made in the Projection for Solar Eclipses are manifested: which consist chiefly in giving, in the Projection, a false Proportion to the Diameters of the Earth, of the Moon, and of the Sun, on one hand, and on the other hand in taking no Notice of the Refraction of Light in the Atmosphere of the Moon; But whereby it appears also, That, if the ordinary Projection accounts

Such Projections Erroneous, by assigning a wrong proportion to the Diameters of ☉, ☽, ⊖, and neglecting the Refr.n of ☽'s Atmosphere.

so nearly for the Phenomena of Solar Eclipses, it is only because the Errors in the Projection are counterballanced by an equivalent Error arising from the Neglect of a due Allowance for the aforesaid Refraction of Light. And this Consideration has afforded me one Method for finding that Refraction: Beside which I have some other Methods for the same Purpose.

These errors more manifest in Occultations of *s by ☽.

26. But as to the Occultation of fixed Stars by the Moon, the Error will remain intire: Neither can it be avoided by any Compensation, but only by an indifferent Knowledge of the Parallax or Distance of the Sun, and a true Knowledge of the Proportion of the real Diameters of the Earth and of the Moon, and of the Refraction in the Horizon of the Moon, and of the Distance of the Moon from the Observator: Now these Particulars cannot be truly and nicely stated without my Theory: But with it they may. Which being done once for all, at least coarsly for the Parallax of the Sun, and nicely for the Diameters of the Earth and of the Moon, and for the Refraction of the Moon's Atmosphere: The Result of it in short will amount to the following Rule.

Requisites to remove them.

Rule to correct them.

27. From the apparent Semidiameter of the Moon, as increased by about two or three Seconds, because of the Refraction in her Atmosphere, substract twice that whole Refraction: And the Remainder will give the Semidiameter of the Circle or Space, in the Celestial Sphere, which is intercepted from our Sight by the Interposition of the Moon: And from hence, and what I have already said, depends the Correction of the Calculations of the Immersion and Emersion of fixed Stars eclipsed by the Moon. But these Stars, moving along the Disc of the Moon, will seem to stick much closer to it, than we find they would do in

in reference to the apparent Disc of the Earth.

Diameters of ☉, ☽, and Hor. Refr. of ☽'s Atmosphere assigned; Different from Sir I.N.

28. I concluded once upon some Suppositions, That the real Semidiameter of the Moon being made of 100 Parts, the real Semidiameter of the Earth must be made of 336,10554 Parts; which Sir Isaac Newton makes of 365 Parts. The Difference is of 28,89446 Parts. From whence I concluded also, That the horizontal Refraction in the Atmosphere of the Moon is of 1' 14'',2746; whose Double is 2' 28'',5492. This I thought fit to mention; it being of the utmost Consequence in determining the Longitude both at Land and at Sea, by Eclipses of fixed Stars. But I intend to revise and publish those or the like Calculations, if God grants me Time and Health; and likewise to facilitate the Use of them, for Mathematicians or Navigators of a moderate Capacity.

Eclipses of ♃'s satellites deficient without the above corrections.

29. But as to the rectifying the Theory of the Satellites of Jupiter or Saturn, by Eclipses of those Planets by the Moon, one of which Eclipses is expected on the 10th of this Month of November; I ~~fin~~ fear that Astronomers will find themselves greatly mistaken, if they neglect, in their Rectifications, what I have now said, or have further to say. For otherwise they may as well perplex and corrupt the Theory of those Satellites, as render it more perfect. Gent. Mag. 1738. p. 8 &c.

N. Facio, Duillier.

Worcester Nov. 12. 1737.

Gent: Mag. p. 12. 1738.

To find the Longitude at Sea.

Let first a Table be made of the Moon's Place at a known Longitude, not by Calculation, but by observing the Moon rise or set, thus:

Method of finding the Longitude by the Moon.

At the first Appearance of her Vertex, if the Sea be smooth, or if rough, I am to be 30 or 40 Foot high, where I can see 8 Miles off, at which Distance the Height of a Wave is inconsiderable, I observe the Hour, Minute, and Second, by a Star, and so, by the Moon's Node, the Difference of their R. Ascension; and suppose it an Hour before 6: Then in the Figure, MN being the Moon's Path, and N the Node, the Angle EPN is 15°, and PE being 90, and PEB the known Latitude, I can find PB, which taken from NP I have BN; also I can find PBE, or EBN, which, with PNM, the Angle the Moon's Path makes with the Meridian the Node is in, will give Nn: Then I want only nC, to know how far the Moon's Center is from the Node, whose Place may be known to 2 or 3 Seconds, tho' the Moon's Place not to half a Degree; if then I substract the Refraction from the Moon's Parallax, and the Minutes the Horizon is depressed by my being 40 Foot high, from the Remainder (which may be known by Wright's Table in his Correction of Errors) I shall know how much the Moon's Vertex, and so her Center, is above the Horizon (i.e.) CO, which, with the Angle n, gives Cn to be added to Nn, and I have her Distance from the Node, or her Place at that Hour by the Node or because the Node is too movable, by the first Star of Aries; and suppose it is 4 Hours

~~Plate~~ Fig. 44.

by the Star the 10th of January, If I add the Moon's periodic Revolution, corrected by the Moon's Apogee, the Node, and the Sun's Place (on which, by Sir Isaac Newton, it depends) I shall have the Moon there again some time in February, and if to that Time I add another Period, I shall have her there again another Time in March, and so through the Year, which will give her Place 12 Times, and if 12 Observations are made, we shall have her Place for 144 Times, and if 30, for 360 Times. A Table being thus made, which the Mariner carries to Sea, he may find the Place of the Node to 2 or 3 Seconds, tho' he knows not his Longitude within 4 Degrees; and as above he may find the Moon's Place, if it happens to be marked in the Table, he hath over-against it the Hour at the known Longitude; if only near it, then as the Moon's horary Motion is to the Difference, so is 13° 60 Minutes to a 4th Number to be added or substracted from the Time in the Tables, according as I find her before or behind.

Note, If he hath the Moon's Place within half a Degree in an Ephemeris, he may also have her Parallax and horary Motion within 2 or 3 Seconds, which will not cause an Error of 360 Seconds, or a Degree in the Longitude, which will come within the Limits set by Act of Parliament: And therefore I hope it will be found I have a Right to the Premium, there being no Instruments to be used to make it impracticable, but only a few Calculations by Trigonometry, which good Logarithms have made easy. Gent. Mag. 1730. p. 12.

Gents Mag. p. 130.

Of the Quantity of the Refraction of Light in the Moon's Atmosphere: And that the Neglect of this Refraction might cause an Error of some Degrees, in determining the Longitude by Eclipses of fixed Stars.

The last Eclipse of Jupiter by the Moon as it appeared at Worcester, and as it must have appeared in other Places of a different Latitude, is abundantly sufficient to demonstrate, That the Rays of Light suffer indeed a very considerable Refraction, in their Passage close to the Moon: and this conformably to my Discourse sent to London November 12, and printed in January 1730, p. 8. (or p. 163 of this book.)

2. As to the Quantity of yt Refraction, (beside what I have mentioned concerning the Moon's Dichotomy &c.) I find it also as follows, by Observations of Eclipses of fixed Stars by the Moon; And likewise by the Observation and Projection of a total Solar Eclipse. In order to which I make the following Preparation.

~~Plate~~ Fig. 45. In the Figure I, let T, L and S, placed in a plane perpendicular to the Ecliptic, and nearly in a right Line TLS, be supposed to be the Centers of the Earth, of the Moon and of the Sun. Let LL and TF be the Semidiameters of the Moon & of the Earth, their Globes being increased by the Effect of the horizontal Refraction in their Atmospheres. And let Tf and Ll be the true Semidiameters of the Earth and of the Moon. Let the Ray of Light TbR suffer a double Refraction in the Atmosphere of the Moon, and touch her Surface in b. And so the Semidiameter of the Moon, as apparent

at

at the Distance LT (or at any other Distance) will be somewhat increased by the Effect of that Refraction. But that Increase, which is very small in the Earth's Atmosphere, will be still much smaller in the Atmosphere of the Moon, so as not to be perceived by us, but with the help of very good Telescopes. Let the right Lines TZA and SZN touch the increased Globe of the Moon, and let SA be perpendicular to TA. And so the Angle STA will be equal to the Semidiameter of the Moon apparent to the Point T. And let SR be perpendicular to the refracted Ray of Light TbR. Let the right Line Ts touch the Surface of the Sun in s: And so the Angle STs will be equal to the Sun's apparent Semidiameter at the Distance TS from his Center. And the Angle RZA will be equal to twice the horizontal Refraction of Light in the Moon's Atmosphere. Let the Semidiameter Tf of the Globe of the Earth be perpendicular to the Plane ST. And thro' the Intersection Z, of the Tangents drawn from S and T, to the increased Globe of the Moon, draw the Line DZPF equal and parallel to TF: And let it cut ST in D. Likewise let SX Tangent of the increased Globe of the Earth cut DF in P and Ff in X. Lastly thro' the Point X draw the Line XNI parallel and equal to FT; and let it cut the Lines SZ and ST in N and I. And transfer the Projection of the Solar Eclipse from DP to IX, that so the Projections of the Earth, for Eclipses of fixed Stars and for Solar Eclipses, may have y^e same Semidiameter TF.

3. In the common Projections for Eclipses of fixed

fixed Stars by the Moon, the Diameters of the Globes of the Moon and of the Earth, as increased by the horizontal Refractions proper to their Atmospheres, ought to have their Proportion always the same, viz. as TF or DF to LL. And this Proportion will differ from the true and natural Propotion of the Diameters of the solid Globes themselves, only by the small Additions like QP or fF &c. made to the Semidiameters of the Earth and of the Moon, upon account of the horizontal Refraction of Light in their Atmospheres. And having now the Knowledge of the Sun's Parallax, and of the Distance ~~betwixt~~ betwixt the Centers of the Earth and of the Moon so nearly; we may already determine pretty well that Proportion and those Additions, even by a proper Observation of a (total) Solar Eclipse. But Astronomers will be much wanting to themselves, not to say to the Public also, if both these Quantities be not accurately known in a short Time, by means of proper Observations of the Passage of the Moon over some fixed Stars.

4. In Eclipses of fixed Stars, the apparent Diameter of the Moon found by Astronomical Instruments, or by accurate Calculations fitted to an exact Theory, is the same as her increased Diameter apparent to the Eye: Which differs very little from her Mathematical apparent Diameter. But the Diameter of the Space hidden by the Moon in the Celestial Sphere must be made a great deal less, in the Projection for Eclipses of fixed Stars, to answer universally the Phenomena of their Immersions and Emersions. And that Diminution amounts always, in the Sphere of fixed Stars, to one and the same Number of Minutes and Seconds, equal to four times the Refraction in the Moon's

Horizon

Horizon. And so the Refraction in the Atmosphere of the Moon may well be found, by making many accurate Observations of proper Eclipses of fixed Stars, whose Places be accurately known: As suppose in her Transit under the Pleiades or Hyades: And N. B. by OBSERVING, at the same Time, most exactly her apparent Diameter. For the Difference between the apparent Diameter of the Moon found then by immediate Observations, and the Diameter of the Space hidden by the Moon in the Celestial Sphere, and which would account best for the Beginnings and Ends of those Eclipses, supposing that the Rays of Light suffered no Refraction in the Moon's Atmosphere; That Difference, I say, will give four times the horizontal Refraction of Light in the Moon's Atmosphere: Which Refraction will by consequence be known. See, in Parker's Ephemeris for 1738, four Transits of the Moon under the Hyades, described for the Month of December 1737, and for the Year 1738.

5. The inlightened Part of the Moon being more than ninety Degrees, by a Zone of about 18 Minutes, we shall have a very long Time, during which we may take promiscuously the Altitudes of both the Limbs of the Moon: And by consequence derive from them her apparent Diameter. For her Diameter perpendicular to the Horizon continues long to be terminated; at both its Ends, by the bright Part of her Limb. This would last for about 36 Minutes of Time, if the Moon did not move towards the East: And will last about one Hour and a Quarter, because of that Motion of the Moon. And thus the taking of Altitudes of the Moon may be sufficient to measure her Apparent Diameter by; without

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the more troublesome Use and Apparatus of Micrometers and longer Telescopes, by whose means however we may come to a greater Exactness. Let then that easy Method, of observing the apparent Diameter of the Moon, be recommended here to Astronomers. For (in the Fig. ~~III.~~ 48.) the Length of the Line TF, drawn from the Center of the Earth to the Focus of the Moon's Orbit, especially in the Winter Area, does not permit us to rely upon the Rule given by Sir Isaac Newton p. 432, concerning the Apparent Diameter of the Moon: Which Rule supposes the Points T and F to be coincident. And indeed that Rule of Sir Isaac Newton is fitted to find the Moon's Diameter apparent to the Focus F; which differs sensibly from her Diameter apparent to the Point T. Wherefore I may say after him, Tentent Astronomi quam probè Newtoni Regula, & Regula hic exhibita, cum Phænomenis congruant.

6. Nay, the very Duration of the Eclipse of one single fixed Star by the Moon, when her Center does seem to pass upon or very near the Star, is sufficient, to discover that Refraction, by means of the Difference of the apparent Diameter (or Diameters) of the Moon found actually by Astronomical Instruments at the Times of Observations, and of the apparent Diameter (or Diameters) of the Space hidden by the Moon in the Sphere of fixed Stars, that would account for the Eclipse of the said Star, did the Rays of Light suffer no Refraction in their close Passage near the Surface of the Moon. For supposing the Moon's horary Motion known, by Observation or otherwise; the Difference, between those two

then given Diameters, of the Moon, and of the Space in the Celestial Sphere intercepted by her Interposition, would be equal to four times the horizontal Refraction in her Atmosphere.

7. So then, in the Projection made upon the Plane IX for an Eclipse of a fixed Star, having CE (Fig. 49.) in Minutes and Seconds, for the Moon's apparent or increased Semidiameter; and CF, in Minutes and Seconds, for the apparent Semidiameter of the Space hidden by the Moon in the Sphere of the fixed Stars, and best fitted to the Universality of the Phenomena; let us describe about the Center C the Circles ſFSſ, and LseEMIiS. And the unchangeable Arc eſ or iS, taken in Minutes and Seconds upon the Radius eC or iC, will always be equal to twice the horizontal Refraction of the Rays of Light in the Moon's Atmosphere.

8. But let the Maps or Tables of the Places of the fixed Stars be wholly made, independently of any Paſsages of the Moon under them. Or else, in the making of those Tables, let a proper Diminution of the Space hidden by the Moon, in the Celestial Sphere, be taken into Consideration. For otherwise we may be exposed to very great and dangerous Errors.

9. Likewise (Fig. 45.) in an ordinary Projection transferred to the Plane XI, for a total or proper Eclipse of the Sun, let a Circle (Rad. NI) represent the Moon, for any Moment during the total Obscuration; according to the Suppositions and Rules, which are commonly followed in those Projections;

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but amended by placing the Center of the Moon at its true Distance from the Center of the Earth: And let another Circle represent the Moon for the same Moment, with her proper Diameter apparent to the Point T, and deduced either from most accurate Observations made during the total Obscuration, or else from Eclipses of fixed Stars, or from an accurate Theory: And I say, That the Angle FXP, or ye Difference between ye 2 Semidiameters of ye Projections, DP and IX, expressed in Minutes and Seconds, will give the Sun's Parallax in reference to the increased Globe of the Earth: While the Angle AZR gives the double of the horizontal Refraction of the Rays of Light in the Moon's Atmosphere.

10. And here we must take particular Notice, that TF being chosen at discretion, in whatsoever Plane FD perpendicular to ST we make a Projection of the increased Globes of the Earth and of the Moon as seen from a fixed Star; the Projection will always remain exactly the same, and have the same Diameters both of the Earth and of the Moon; and all the same Lineaments, becuase of the vast Distance of those Stars from us. And this will hold true, whether the Distance TD be never so small, as suppose equal to TI: Or whether it be, for instance, of 65, or 1000 Semidiameters of the Earth.

11. But in reference to a Projection drawn upon the Plane DF for a Solar Eclipse, the Case is not so. For then the Eye is supposed in the Center of the Sun S: And the Tangent SPX determines the Semidiameter of the Projection of the Earth as seen from S to be equal to DP, while the Semidiameter DZ of the Projection of the Moon upon the Plane DF or DP remains sensibly equal to

to LL, or inconsiderably bigger. And therefore if we increase the Projection made upon the Plane DP for a Solar Eclipse, so as to give to it the same Semidiameter IX as we dis chuse for the Projection for Eclipses of fixed Stars, we must increase in it the Semidiameter of the Moon proportionally, by saying, as the Distance SD, is to DZ, so is the Distance SI, to IN, which will be the Semidiameter of the Moon, in the Projection for a Solar Eclipse. As to the Lineaments of the Projection, they will be somewhat changed indeed: But that Change needs not be taken notice of, till a proper Occasion requires it.

12. Thus, in the two Projections of the Earth made upon the Plane IX, and having the Line IX for Radius, the Semidiameter of the Moon will be equal to LL for Eclipses of fixed Stars; But it will be equal to IN for Eclipses of the Sun. And, As ST in Semidiameters of the Earth, Is to TF, So will be the Radius, To the Sine of the Angle TSX, or of the Parallax of the Sun in reference to the increased Globe of the Earth.

13. Let the Line TS cut the Line DP in V: And DV will represent, in the Projection DP, the true Semidiameter of the Sun apparent to the Point T; while the Semidiameter of the Moon apparent to the Point T is represented, in the same Projection, by the Line DZ. Let the Line SV cut the Line XI in K: And IK will represent, in the Projection IX, the Semidiameter of the Sun apparent to the Point T, while IN

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represents, in the same Projection, the Semidiameter of the Moon apparent to the same Point T.

14. But let the Reader take notice that, in the Figure, the perpendicular Lines as ST are represented vastly too short in reference to the horizontal Lines as FD. And that the Line LT, which was in the total Eclipse 1715 about $\frac{1}{24}$ of ST, is also much longer in the Figure, than it should be in reference to ST. And that likewise LT, which in the Figure is shorter than TF, was in reality about 65 times longer than TF. The Things which were to be represented, and the Smallness of the Figure, did cause this Difformity, which however will in a manner disappear, if it be conceived that the Line TS being in reality about 1600 Times longer than TF in the Figure, is turned with the Sun about the Axis TF, till TS being seen from an infinite Distance by an Eye placed perpendicularly over the Point T, and so being projected in this Figure, it be reduced to the small Standard TS.

15. It were to be wished that in the said Eclipse, or in the like total Eclipses, which appear so rarely, the apparent Diameter of the Moon had been observed with care, during the total Obscuration. For that Observation would have been very curious in its Kind, and very instructive, chiefly in reference to the Refraction of Light in the Atmosphere of the Moon, and to the Distance at which she was then from us. However this Defect may be pretty well supplied from the very Phanomena of that Solar Eclipse, compared with my Demonstrations and Theory about the Parallax of the Sun, and about the Dis-

Distance betwixt the Centers of the Moon & of the Earth. But I am afraid that the Calculations which I have actually made concerning this Subject, would appear too long and too composed for the Readers of this Magazine. And so I leave the few learned Astronomers, that are able to make the like Calculations, and who may differ as yet from ~~[illegible]~~ me in determining the Distance of the Moon, to take the same Pains themselves, which they will find joined with no small Pleasure. In the mean while I reckon that the horizontal Refraction of the Rays of Light in the Moon's Atmosphere may be supposed of 1' 6" whose double is 2' 12".

16. The Readers may perhaps be amazed that I should say here; That Jupiter appeared actually eclipsed by the Moon, on November the 18th at Worcester or in the Neighbourhood. For Mr John Dougharty junior observed it at the ~~[illegible]~~ Place called The Old House Farm, in ye Parish of Norton, at about three measured Miles South East from Worcester; and that with a Glass of about four Feet two Inches, having three convex Ocular Glasses. He and his Father place, by their Observations, Worcester at 52° 20' Latitude; and 9 Minutes West Longitude from London. By the Observation made at the Old House Farm, the Immersion was at 7 Hours 17 Minutes apparent Time, measured by a Watch, and the Emersion at 7 Hours 30 Minutes. And the total Occultation lasted 13 Minutes. This agrees with my own Observations, and agrees pretty well with the Place (in Mr Dougharty's Scheme) where he saw the Beginning of the Emersion upon the Limb of the Moon.

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For he places it at about 75 Degrees from the upper Horn. And I doubt not but all this will agree with the Observations made at London, if they have not been given over too soon. I made use of a small Telescope of four Inches: And for a considerable Time I saw Jupiter describe nearly a Line perpendicular to the rectilinear Section of the Moon (for she was about her Quadrature) And that Line was directed seemingly to the upper Corner or Horn of the Moon. So I continued to observe, till the right Line which terminated the bright Part of the Moon came up to Jupiter. And then, seeing that he was visible still, tho' very near to the Body of the Moon, and forgetting my own Theory of the Refraction of Light in ye. Moon's Atmosphere, as well as the Obliquity of about 22° 47', of the Section of the Moon with the Meridian passing thro' Jupiter, I gave over my Observation for good and all: When, it seems, I ought to have looked upon it as just begun. Neither could I be sensible of my Mistake, till I saw Mr Dougharty's Scheme.

17. London lies 40'. more southerly than Worcester. But it would be requisite to make a Scheme of this Eclipse of Jupiter according to the best Rules, and agreeably to the Observations made near Worcester, or any where else. And then we may safely determine the horizontal Refraction of Light in the Moon's Atmosphere. And then also we may certainly judge whether those learned and curious Observators at London, who could see no Occultation of Jupiter, tho' they saw the full Orbs of Jupiter and of the Moon during what they call

call their *Praeterition*, did fall into the same Mistake with myself. For, by what Mr *Cave* has writ^t^en to me, I conceive that the Distance of *Jupiter* from the Moon, which was more than two Diameters of *his Body* as observed with a Telescope at *London*; was seen when *his Center* was in the Line that terminated the inlightened Part of the Moon. And even this does yield a strong Suspicion that the total Eclipse of *Jupiter* was visible at *London*.

18. But as this *Discourse* is too long already, I intend to shew distinctly at another Time, How great are the Errors and Uncertainties to which we must be exposed in deriving the Place of an Observator at Land, or of a Ship, or of a Fleet at Sea, if we neglect that Refraction so often mentioned. For I reckon that the Errors and Uncertainties may amount to several *Degrees* in *Longitude*, and, in certain Cases, to 4 Minutes and $\frac{2}{5}$ in Latitude. In short this Neglect has greatly perplexed and corrupted the Astronomy of the Moon. And upon that accout I do not wonder that the Errors, in the *Calculations* of the Place of the Moon, do amount sometimes to four Minutes and a half, as Dr *Halley* told me in 17[illegible]0. Of which Error I hope the greatest Part may now be avoided, but much more when I have publish'd what I have to say about what I call here enigmatically LVD, or 544. Gent. Mag. 1738 p. 130. &c.

Worcester. Feb. 8, 1738. N. Facio, Duillier.

Gent's Mag. p. 185: for 1738.

Of the Quantity of the Errors arising in the Determination of of the Latitude and Longitude, from the Neglect of the Refraction of Light in the Moon's Atmosphere.

~~Plate~~ Fig. 6. 1. IF the Moon, represented by the Globe MEesOLoSiIM whose Center is C, was always at the same Distance from the Observat~~ors~~ Eye; Then, in the Sphere of the fixed Stars, the concentric Circle FſOoNSF, comprehending all the Stars hidden by the Interposition of the Moon, would always be of the same Bigness, and at the same Distance from the apparent Limb of the Moon.

A mistake in this discourse is corrected at p. 196.

2. And tho' the Moon were nearer to, or farther off from the Observator, yet the double Refraction of a Ray of Light passing close to the Body of the Moon, would always be the same: And MF, in the Sphere of the fixed Stars, would always remain the same also, namely, the Difference between CM the increased apparent Semidiameter of the Moon, and CF the Semidiameter of the Space eclipsed by the Moon: Which MF we may suppose of 2′ 12″, that is of 132 Seconds.

3. In the Spherical Triangle PCO, let PC be the apparent Distance of the Moon from the North Pole P: Which Distance is here supposed of 63 Degrees only, for sometimes it does not exceed 63 Degrees. Let the Distance FD of the Point F, from the right Line or Chord Ss perpendicular to PC, be also made of 132″, or equal to MF, expon(ent) of double the horizontal Refraction in the Moon's

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Atmosphere. And, in order to give an easy Example, let the Tangent IFE perpendicular to PC subtend the Arc IME of sixty Degrees. And then, As ye Versed Sine of [illegible], 30°, Is to ye Radius; So will be MF or 132", To MC or CO, the apparent Semidiameter of the Moon, which would be found of 16' 25" 1/4. And to the Apparent Semidiameter, which returns frequently, the following Example is accommodated.

4. About the Pole P of the Equator, draw the Parallel Circle to it DO, which cuts the apparent Limb MEL in O. And in the Spherical Triangle PCO, the three Sides will be given, PC = 63°; CO = 16' 25" 1/4; and OP = DP = 63° 12' 1" 1/4. And therefore the Angle CPO will be found of 12' 31",916. In which Calculation it appears how much my Two Methods, by Versed Sines, are preferable to the common Trigonometrical Rules.

5. And As the Radius, Is to the Sine of OP, So are 751",916 contained in the Arc DO (as well as in the Angle DPO) To 671",17, or to 11' 11",17 = DO expressed in Parts of a Great Circle.

6. Now let us suppose that the Observations be made at Land, and even in Royal Observatories, and with the best Instruments of all Sorts, and that all the required Data be perfectly known: That so we may better perceive what the Errors and Uncertainties, arising barely from the Neglect of the Horizontal Refraction in the Atmosphere of the Moon, may amount to, both in the Longitude

and

and in y^e Latitude. For it is evident that the Observations made at Sea may be more, but not less uncertain than those made at Land.

7. Of these Data, being in Number about twelve, some depend upon one another. But by my Theory, and by the Tables or Observations of fixed Stars, they may be all sufficiently known, in order to establish this my Calculation, which may also serve for an instructive Example of the Calculations that may be made, in any other the like particular Case.

8. It is evident that if the Star, that is known to describe the Parallel DO, does either not at all disappear in M, or does only disappear near M for a very small or insensible Time, the Observator will be induced to conclude, That the Center of the Moon was at least 4' 24" more South than it really was, since the Star, as far as he knows, was not eclipsed at all.

9. And another known Star, passing about the same Time on the other Side of the Center C, at a Distance from it equal to CD, would induce another, or the same Observator to conclude, That the Center of the Moon was at least 4' 24" more North then it really was, since the Star did also seem not to be eclipsed at all, when in or near the opposite Point N.

10. So we must leave those two Observators disputing, if you will, in Presence of a Flag-Officer, or else in a Royal Observatory, and differing from one another upon the best Astronomical Grounds, in the observed Declination of the Moon, by even more than 8' 24"; till they reconcile themselves by other Observations, or by having recourse to the Refraction made in the Atmosphere of the Moon.

Moon. And this may suffice, in this Case, concerning the Uncertainties and Errors in the Latitude. For surely they will not venture to conclude, that the apparent Diameter of the Moon was only of twice DC, or equal to 24′ 2″ ½: And, besides, it would be easy to find the contrary by immediate Observation.

11. As to the Longitude; the Errors and Uncertainties might be much greater. For a Star seeming to disappear for a short or insensible Time in M or near N, would really describe the Arc or Curve DO or Do parallel to the Equator very nearly. And so, by a most accurate Calculation, the Star might be eclipsed during about twice the Time which the Moon spends in advancing Eastward from the Star by the Angle CPO or CPo, if the Refraction made in the Moon's Atmosphere might be neglected. And yet, by a real and accurate Observation, the Moon might pass by the Star, without eclipseing it at all near M or N: Or else, the Star might be eclipsed near M or N only for a very short or even insensible Time.

12. Thus, in this Example, by resolving the Spherical Triangle CPO, the Moon might be concluded, by Calculation, to eclipse the Star near S sooner, or to eclipse it in O later, than it might really disappear, or emerge, near M, by almost the whole Time which she spends in describing in her Orbit, by her periodical Motion Eastward

ward, the Angle CPO, or 12' 31'', 92 in right Ascension measured about the Pole P by the Arc DO, in reference to the fixed Stars. Which Arc expressed in Parts of a great Circle comes to 11' 11'', 17; and, by a Medium, may well require 22 Minutes Time, or else, considerably more, for its Description. Now an Error of 22 Minutes in Time would cause an Error of 5 Degrees 30' in Longitude. And, As the Radius, Is to the Sine of the Latitude of the Place of Observation; So would be the Sine of 5° 30'; To the Sine of the Error in Longitude reduced into Minutes or Marine Miles of 60 in a Degree of a great Circle; supposing the Earth to be Spherical. And so, upon the whole, the Error, in the concluded Longitude of the Place of Observation, might well amount to or exceed three hundred Geographical Miles of sixty in a Degree, For the Difference of about three Minutes fifty-six Seconds between one Revolution of the fixed Stars and one Solar Day, which is neglected here, would make the Error still greater. And likewise in the Triangle CPo, the Angle CPo would be found of 12' 33'' $\frac{1}{4}$. But the Angle CPO would be of 8' 31'', 19$\frac{4}{9}$; and the Angle CPo of 8' 32'', 11$\frac{1}{2}$.

13. As to the least Errors in the Longitude; which may be caused by a double horizontal Refraction of Sight in the Moon's Atmosphere; they would never amount to less than does result from the Time required for the Moon to advance in her proper Motion Eastward, by 2' 24''. Now, by the ordinary Tables, she does advance in her Orbit at most 38 Minutes in one Hour, and at least

least 28 Minutes: And so the least Error in Longitude would be, in the first Case, of 3 Min. 47,37 Seconds; and, in the second Case, of 5 Min. 8,57 Seconds of Time.

14. But if we would have a general View of these Errors in Longitude and Latitude, the best Method would be to make a proper Projection of ye Globe of ye Earth, as seen from the Sphere of the fixed Stars, taking for Foundation all its Data corrected by our New Theory, and among them the true Diameter of that Space in the Sphere of the fixed Stars, which the refracted Rays of Light, passing to or from the Observator, close by the Surface of the Moon, cannot reach.

15. For all these Errors, as far as they arise only from the aforesaid Refraction, would be prevented by supposing the apparent Diameter of the Moon to be smaller than it does really appear, or than a most accurate Theory would give it; and that, as I reckon it, by 4' 24". An enormous Difference! whereof Astronomers did not so much as suspect, or hope, that this its true and only Cause should ever be found.

16. And whereas Dr Halley told me in 1728, That the Theory of the Moon did enable us to calculate the apparent Place of the Moon within 4 1/2 Minutes, the Errors of the Tables included: I cannot but take Notice that accordingly, notwithstanding the great and dangerous Influence

-fluence of that Refraction upon the Longitude, or upon the Moments of Immersions or Emersions of fixed Stars eclipsed by the Moon; yet its Effect does never remove the apparent Places of the fixed Stars, from their true Places, by a greater Space than 4′ 24″ at most; taking this for double the horizontal Refraction in the Moon's Atmosphere. For sometimes that Removal is scarcely sensible at all; namely, when the Rays of Light coming from the Star do not pass quite close by the Surface of the Moon,

17. It were to be wished that, beside the other Errors arising from that Refraction so often mentioned, it had not occasioned innumerable Difficulties and Errors, in the Calculations of the Places of fixed Stars eclipsed by the Moon; and of the Places of the Moon, at the Moments when those Eclipses did begin or end. And therefore may those excellent and laborious Astronomers, who have employed themselves in making Tables of the Places of the fixed Stars, have Time to revise and correct them; at least as far as this so long concealed Refraction may have occasioned any Errors in them! For if that cannot be done, the whole Work, in reference to the Zodiacal Stars, must be revised, or begun again. And the Places of all those fixed Stars must be ascertained, by whose Eclipses, or the near Passage of the Moon to them, the Longitude may possibly be found. This Work may be soon dispatched; if Astronomers will set in earnest

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about it; and do either find, or else do not despise those necessary and numerous Directions which may possibly be given them, in order to finish quickly the Work; and to render it more safe and perfect.

18. As for Soverigns and Legislators, they have it in their Power to direct, if they please, and encourage accurate Astronomers, to go on as soon as possible thro' so very useful and profitable a Work. For upon it, under God's Providence, may depend in some Measure the Prosperity and Quickness of their Navigation, the Fortune of their Merchants, and the Lives of their Mariners, and of the Sea-faring People who are exposed to the same Dangers with them.

19. Many of the numerous Equations, which Sir Isaac Newton brought into the Theory of the Moon, will be greatly affected, by the Difference of the Elements or Foundations which he built upon, from those truer ones which result from our Demonstrations. And some of those Equations (by whose means he comes often to a true Conclusion, notwithstanding his fundamental Mistakes) would necessarily lead us into Errors, if they were admitted indifferently into our truer Theory. But before I consider these Things further, I intend, if God please, to publish, and that perhaps in my next Discourse, another fundamental Theorem, of the greatest Consequence for perfecting the Moon's Theory: And whose Use, in reference to all passed or future Observations of the Moon, is really inestimable; as all sincere Astronomers will readily confess. Gent. Mag. 1738. p. 185 &c.

Worcester
March 29, 1738.

N. Facio Duillier.

A correction of a Mistake in the Discourse began on p. 188. from the Gents Mag. N°265. 1738.

In my Discourse supra, there is a Mistake, occasioned by my having chosen, for facility sake, to make FD equal to FM; which made me, by Inadvertency, suppose absurdly that a Star placed in D did disappear in F. This Mistake has made me to magnifie too much the Errors in Longitude and Latitude, which the Refraction of Light in the Moon's Atmosphere exposes us to. I wish it had rather made me to extenuate them. However, that Mistake being amended, the Discourse will remain sound, as well as the New Conclusions drawn from it.

2. I intended to prevent any such Mistake, by communicating beforehand my Discourses to some proper Judges. But one would think that those Persons who might be Judges are unanimously resolved to have nothing to do with my Theory: Nor can I learn as yet that there is any One, that does openly declare for it. Therefore, since I must do the whole Work alone, I hope the Publick and yourself will forgive me any such Mistakes, and accept of my rectifying them as soon as I can, as I do here.

Fig 16. ~~of Plate~~

3. Upon the Diameter FN take FD of any length. And about the Pole P draw thro' the Point F the Arc Fe, which cuts the Limb of the Moon in the Points i and e, and the Arc DOO, which cuts the Circle FLON in O and the Limb in O. And in the Triangle CPe, I find the Angle CPe or the Arc Fe to be of 9' 12",3: This Arc, expressed in Parts of a great Circle gives Fe of 8' 12",1. And to describe this Arc, the Moon would require 17 minutes 34 seconds, if we reckon her horary Motion at 28'; or else 12 minutes 57 Seconds, if we reckon her horary Motion at 38'. In the first case, the Error in

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Longitude would exceed 4° 17'; and in the second case, it would exceed 3° 3'. All the other horary Motions are limited between these. And the Error resulting from any other horary Motion of the Moon, at the Time of the Observation, may be in like manner determined.

4. But taking FD for instance of 2' 12", I find, in the Triangle CPO, the Angle CPO, or the Arc DO to be of 12' 31",9: And that the Angle CP$\underline{O}$ would be of 8' 31",2. Now let the Line CO$\underline{z}$ cut the Limb in $\underline{z}$: And as soon as the Star comes to $\underline{O}$ it will emerge in $\underline{z}$. The Difference O$\underline{O}$ is of 4' 0",7. And so the little Arc O$\underline{O}$ expressed in Parts of a great Circle amounts to 3' 34",9, for the Argument of the Error in Longitude. For the Astronomical Calculation gives the Emersion when the Star is in or very near the Point O: But in reality, the Emersion happens when the Star is in the Point $\underline{O}$. And therefore if the Moon's horary Motion was of 28', the Error in Longitude, or the Time spent in describing the Arc $\underline{O}$O, would be of 7 min. 40 $\frac{4}{9}$ sec. which amount to an Error of 1° 48' $\frac{2}{8}$ of Longitude. And the horary Motion of 38' would produce an Error in Longitude of 5 min. 39 $\frac{1}{4}$ sec. in Time, or of 1° 17' $\frac{3}{5}$. And in like manner we may find the Error in Longitude resulting from any other given horary Motion of the Moon.

5. Likewise making CD equal to CD, I find, in the Triangle CPo, the Angle CPo or the

the Arc Do to be of 12' 33",3. But the Angle CPo would be of 8' 32",1. The Difference oo is of 4' 1",1½, and by consequence almost the very same as OO. And the Error in Longitude would be found almost the same as before.

6. As to the Error in Latitude, it can amount at most, only to the Arc MF of 2' 12", taking 1' 6" for the horizontal Refraction of Light in the Atmosphere of the Moon. And you may take the following Rule.

7. Let a Star describe any given Parallel DoO, cutting the Circle FLON in O. Draw the Line COz, which cuts the Limb MEL in z. And in the Triangle PCO, the three Sides being given, calculate the Angle PCO or PCz. Then in the Triangle PCz, the Sides PC and Cz and the Angle PCz being given, calculate the Basis Pz. And since the Star coming to O emerges in z, and the Astronomical Calculation makes it more truely to emerge in O; it follows that ye Observation shews the Emersion, as if the Parallel of the Star passed thro' z; and by consequence as if the Moon's Declination PC, or the Situation of her Center C was changed, till the Point z of her Limb was brought, by a Circle Parallel to MP, to the Parallel DoO. And thus you will find how much the Refraction alters your Latitude, or the apparent Distance of the Center of the Moon from the Pole: For these two Quantities depend upon one another. Gent. Mag. 1738. p. 265.

N. Facio, Duillier.

Worcester,
May 15. 1738.

Subject Continued on p. 208.

(199)

From Gent's Mag. p. 263. 1738.

Mr. URBAN,

IT has long been a Question among Astronomers, Whether the Obliquity of the Ecliptick has always continued the same, or whether it has been subject to some little Variation? Those who suppose it to be invariable, ascribe the different Accounts of it to the Inaccuracy of the Instruments made use of the Ancients, and not to any Alteration in the Obliquity itself. But tho' we should allow the Observers of former Times to have been deficient in their Enquiries, what shall we say to the Difference we find among the Moderns, whose Instruments have been contrived with the nicest Art, and adjusted with the greatest Accuracy? It is not much above 50 Years ago since Flamstead, Cassini, de la Hire, and other excellent Astronomers have determined the Sun's greatest Declination to be 23° 29' precisely, and the Great Tycho Brahe himself differs from them only on account of his wrong Notion of the Sun's Parallax and Refraction; and yet Maraldi, and the rest of the French Astronomers, have lately asserted, that it is no more than 23° 28' 20", that is, 40 Seconds less than Mr. Flamstead's Determination.

But that this Matter may be more fully comprehended, I shall give your Readers a Synopsis of the most remarkable Observations that have been hitherto made concerning it.

The Sun's greatest Declination was observed to be

In the Year since the Death of Alexander the Great March 21st. 323 A. C.

[illegible] 323 A.C.	44	by Aristarchus	23°	51'	20"	
						Interval 70 y.rs 0'.0".
	114	Eratosthenes	23	51	20	
						Inter. 60 —
	174	Hipparchus	23	51	20	
		In the Year of our Lord				Interv. 289 y.rs — 0'.0"
	140	by Ptolomy	23°	51'	20"	
						Inter. 740 y.rs — 16'.20" — 1",32 p. y.
	880	Albategnius	23	35	00	
						— 190 — 1.0 — 0,31
	1070	Arzacheles	23	34	00	
						— 70 — 1,0 — 0,86
	1140	Almeoneo	23	33	00	
	✓ 1100	Prophatius	23	32	00	
	1460	Peurbachius	23	28	00	
						— 55 + 0.24 — +0,44
	1515	Copernicus	23	28	24	
						— 81 — +3.6 — +2,30
	1596	Tycho	23	31	30	
						— 4 — 0.30 — 7,50
	1600	Clavius	23	30	00	
						— 20 — 0.0 — 0,0
	1620	Kepler	23	30	00	
						— 70 — 1,0 — 0,86
	1690	Flamstead	23	29	00	
						— 47 — 0.40 — 0,85
	1737	Maraldi	23	28	20	

Now I have thought of a Method that will go a great Way towards the Determination of this Dispute, especially with regard to the later Observations, and this is to be done by a Quadrant, the Radius of which is no less than six Miles in Length. I make no doubt, but at first Sight this will be taken to be nothing but a wild Chimera, and yet nothing upon Examination will appear more plain or practicable. What I mean, is a Solar Occultation behind a Hill called the Cloud, on the Borders of Staffordshire; which Dr Plot has given the World an Account of about 60 years ago.* This Hill is so situated with respect to the Church-yard of Leek, a Market-Town in the same County, and six Miles distant from the Hill, that a Spectator standing there of an Evening three or four Days before the 10th of June, when the Sun enters the Beginning of

* See his Nat. Hist. of Staffordshire, p. 2.

of Cancer, beholds the Disk of the Sun gradually emerging from behind the Northward Side of the Hill, which is nearly perpendicular; and this in such a manner, that a very sensible Difference is perceived in the Sun's Motion every Evening, and at length the whole Disk emerges for three Days together, but the second very evidently more distant than the first and last. Now as the Sun's Declination on those three Days does not vary above one third of a Minute, it will be very easy to discover, whether the Obliquity of the Ecliptic is the same as it was in Dr Plot's Time, or not: For if it is but 23° 28' 20", as the French Astronomers assert, then the Sun's Disk will not intirely emerge from behind the Hill, unless Mr. Flamstead's Observations were faulty: But if the Emersion is entire, and for three Days only, as formerly, we may then reasonably conclude, that the greatest Obliquity has been invariable for 60 Years at least, and if for 60, why not for 6,000? However, this Solar Occultation will be a very agreeable Sight to the Curious who reside in those Parts, and if they transmit their Observations to you to be communicated to the Publick, it will be a very acceptable Favour to all Lovers of Astronomical Enquiries. (Gent. Mag. 1738. p. 263.)

See p. 310. Yours &c. R. Brookes.

Leek, ~~Leek~~, June 26

From Gents Mag. p. 310. 1738.

To the Lovers of Astronomical Enquiries.

IT is our annual Custom to make Observations from our Church-yard of the Sun's setting some Nights before and after the 10th of June, and there's no Person now living that has discovered the least Variation in its Course, but as it gradually moves to its utmost Point, so it returns in the same manner; and that the Curious may have the better Idea how it appears to us I have sent you a Plan. See Fig. 47. ~~on plate~~ The only ocular Observation that could be made this Year was the 7th, all the other Evenings now Cloudy.

Gent. Mag: 1738. p. 310.

From Gents Mag. p. 368. (1738.)

The four following Schemes Fig. 47. ~~on plate~~ represent the four Successive Phases of the Sun in his Approach to, or Recess from the Summer Tropic, as he gradually emerges from, or absconds behind a Hill in Staffordshire called the Cloud 6 Miles distant from a Spectator in Leek Church-yard, as it has been observed from thence many Years, for 2 or 3 Days before and after the 10th of June. (See p. 199 ~~[illegible]~~.) Gent. Mag. 1738. p. 368.

Mr URBAN,

Ib. p. 167.

I Am very glad to find by your Correspondents Answer from Leek, that the Obliquity of the Ecliptick has been invariable, as long, at least, as the oldest Person in that Town can

can remember; for if there had been any Decrease, which is the thing in Question, it must have been very visible even to the naked Eye. The Reason of this is very evident, because the Distance of six Miles renders the Observation much more plain and accurate, than can possibly be taken by the nicest Instument ever yet invented: For what Proportion does six Feet bear to six Miles? It is as one to 5280. This I think leaves no doubt of the Certainty and Conclusiveness of this Method. But to put this Matter farther out of Doubt, I shall make it appear from the Observations of the most expert Astronomers, that the Sun's greatest Inclination has continu'd invariable for this 150 Years past.

I believe the Observations of Tycho Brahe are liable to least Objection of any Astronomer of his Time; he determined the Latitude of Uraniburgh to be 55° 54' 30"; hence the Altitude of the Equator 34° 5' 30"; the greatest Meridian Altitude at the Summer Solstice 57° 35': From which the Flamstedian Refraction being deducted, leaves the true Height of the Sun 57° 34' 33"; from this substract the Height of the Equator, there will remain the greatest Obliquity of the Ecliptick 23° 29' 3":

Then again at the Winter Solstice,

The Alt. of the Sun Dec. 11. was	10° 41' 10"
Refraction substract — — — —	4' 15"
Rem.r the Sun's true Alt. — —	10° 36' 55"
which substracted from the Alt. of the Equator }	34° 5' 40"
Leaves — — — — — — —	23° 28' 45"

From

From these Instances it plainly appears the greatest Obliquity could not be 23° 31' 30" as Tycho asserted; whose Error arose chiefly from a Supposition, that the Sun's Parallax was much greater than it really was; but by later Observations, and consequently more accurate it has been found to be almost insensible; for which Reason I have ~~also~~ wholly neglected it.

In the Years 1594, 1595, 1596, and 1597 our own Countryman, Mr Ed. Wright, observed the Sun's Meridian Altitude with a Quadrant of more than six Feet Radius. From him we have the commonly receiv'd Notion that the Latitude of London near the Tower, is, 51° 32', but how justly will appear hereafter. And that has been swallow'd down by all Astronomical Writers without Examination ever since. The only Observations to be depended upon, which have been made near London, have been taken by Mr Flamstead and Mr Pound; the former determined the Latitude of the Observatory at Greenwich to be 51° 28' 30", and the later that of Wanstead 51° 34'. Now the last and best Survey of Essex places Wanstead at least 3' 30" more North than the Tower; and the Observatory at Greenwich is not more than 2' more Southerly than the same Place. Hence the Latitude of the Tower of London cannot exceed 51° 30' 30", and the Altitude of the Equator 38° 29' 30": This being substracted from the greatest Meridian Altitude, observ'd by Mr Wright, leaves no more than 23° 28' 30" for the greatest apparent Obliquity; which is a few Seconds less than that of Tycho his Contemporary.

From these Observations therefore rightly appre

applied, we may safely conclude that the greatest Obliquity of the Ecliptick in Tycho's Time, did not exceed what Mr Flamstead found it to be near 100 Years afterwards; and as for the Time elapsed since Mr Flamstead began to observe, the annual Observations at Leek are a sufficient Proof that it has been invariable since. The only remaining Difficulty is that of Maraldi, who in the Connoissance de Temps has reduced the Obliquity to 23° 28′ 20″, and this can be accounted for no other Way, if his Observations are equally accurate, than by his allowing a greater Refraction than Mr Flamstead, as the two Cassini's, Father and Son, did before him. And as for the Latitude of London, the Alteration I have made, is built upon such a rational Foundation, that no one will call it in Question who has a sincere Regard for the Discovery of Truth. And indeed I have often wonder'd that so important an Enquiry has never been determined with greater Accuracy before now: Nay, what is more in a Nation wherein so many are qualified for Enquiries of this sort, there are not five Places in England, determin'd to so great a Degree of Certainty as is requisite in Cases of this Nature. Nor can the Authors of the latest County-Surveys be acquitted of this Charge; since, however exact their Measuring may be, as to Latitude, they are all inconsistent with each other. And certainly there cannot be a greater Reproach to this Nation, considering how diligent our Neighbours y^e French are in correcting all Errors of this Kind,

Kind, and what an exact Map of their Country the Academy of Sciences have exhibited to the Public. However I am greatly pleased to learn by Mr Facio's Means that all Persons are not equally indolent in Determinations of this Kind, and that the Dougharty's have taken some Pains in determining the Latitude of Worcester. And since the Royal Society as a Body seem to decline this Trouble, if other qualify'd Persons would follow so laudable an Example, we might soon be enabled to give the World a much more correct Map of England than as ever yet appear=ed. I am yours, &c. R. BROOKES. Gent. Mag. 1738. p. 467 &c.

P.S. Your Astronomical Readers will easily perceive that what I have said hitherto, is not so much to determine the exact Quantity of the Obliquity of the Ecliptic, as to shew that it is invariable, and what Reason there is to dissent from the Determination of ye French Astrono=mers; they having asserted, that the Circle of the Ecliptic approaches the Equator at the Rate of 1 Min. in 90 Years*. For certainly such a considerable Decrease could not escape the Observation of the Curious at Leak, by Means of that very remarkable Hill mentioned in my last. The Skilful in these Matters will readily find that the Increase of the Sun's Declination, on the Day of his touching the Tropick of Cancer, cannot amount to more than 14", not 20", as I before asserted by Mistake; ~~and consequently~~ as the Sun continues to emerge from behind the Hill, viz. one Day only, in a distinct manner, as in Dr. Platt's Time, it cannot have decreased 40" as it must have done, if the abovemention'd Hypothesis were true; since that Number exceeds the said

divi-

* See the Memoirs De l'Acad. for 1734.

diurnal Encrease of Declination no less than 26". And as to the Observations of the Ancients we have none left but those communicated by Ptolomy; and how little he is to be depended upon appears from his Error in the Latitude of Alexandria, the Place of his Habitation, which he made no less than 13 Min. more than M. Chazelles has yet found it. To this I shall add the Opinion of the compleatest Astronomers any Age ever produc'd, I mean Dr HALLEY: His Words are these, † But whether it were really true, that the Obliquity of the Ecliptic was, in the Time of Hipparchus and Ptolomy, really 22 Min. greater than now, may ~~be~~ well be question'd, since Pappus Alexandrinus, who lived but about 200 Years after Ptolomy, makes it the very same that we do. Upon the whole then I must leave it to the Consideration of the Judicious, Whether this pretended Decrease of the Obliquity of the Eclipticks, is not much more properly to be attributed to the Inaccuracy of Instruments, and the different Tables of Refraction, than any real Motion in the Circle itself? And whether there can possibly be invented a more certain Method of determining this very important Point, than what I have, by your Means, exhibited to the Publick?

† Philosophical Transactions, N°355.

~~See p. 264, 268, & 310~~

From the Gents Mag. p. 95. 1738.

An Impartial and clear Decision of the Controversy, between the Followers of Sir I. Newton, and Mr. Facio, concerning the Sun's Parallax.

I Publish now a most easy and decisive Method of observing the Sun's Parallax, that I may overcome, at once, those almost universal Prejudices, which would not yield, hitherto, even to the clearest Demonstrations.

2. I was not quite eighteen Years old, when I did write down this Method, in a long Letter directed from Geneva to the illustrious Monsieur Cassini: It contained some Mathematical and Astronomical Discoveries, as I conceived; and among them the Method of finding the Parallax of the Sun, by the Distance between Time, or the Place, wherein the Light of the Moon seems terminated by a right Line, and the Time or the Place of the Moon's coming to her Quadrature.

3. I demonstrated, in the same Letter to Monsieur Cassini, the Theorem which I had then discovered, and which has enabled me to find the Sun's parallax, namely, That two Points S and T being given; and the Line SL being to LT in a given Proportion; the Locus of the Point L is a given Spherical Surface. So early did Providence give a Sign, or Token, of her manifesting one Day, as she does now to Mankind, that Great and abstruse Secret, so long and so earnestly sought for, but which hitherto has been an Occasion of great, not to say prodigious, Errors! And in that Letter I demonstrated also, from the straight Fascia, which Mr Hugens had so often observed in the middle of the Globe of Saturn, that the Axis of that Planet, about which it may be supposed to revolve, must be sensibly parallel to the Plane of Saturn's periodical Orbit.

I think this refers to fig. 45 ~~on plate~~ 45.

4. Monsieur Cassini's Answer was very kind, and disposed me to go to Paris in April 1682. But as he was prepossessed with the prevailing Opinion, That the Parallax of the Sun was very small; he concluded, in his Answer, that it could not be be found by this Method.

5. I say then, at present, that the Sun's Parallax may be easily found, by means of the Arc in the heavenly Sphere, intercepted between the two apparent Places of the Center of the Moon, when her Light seems terminated by a right Line, and when she comes to her apparent Quadrature.

6. Or else, in other equivalent Terms, I say, That the Sun's Parallax may be easily found, by means of the Time intercepted between the Two Moments when the Light of the Moon seems terminated by a right Line, and when she comes to her apparent Astronomical Quadrature.

7. When ye Section or Limit yt divides ye dark Part of the Moon from her inlightened Part appears as a right Line; then, the Line drawn from S the Center of the Sun, to L the Center of the Moon, is perpendicular to the Plane of that Section. And the Observator's Place being called O, the Measure of the Parallactic Angle LSO depends on the Distance betwixt the Centers of the Sun and of the Moon; or (which comes to the same) on the Distance betwixt the Center of the Sun and the Observator.

8. If the Sun's Parallax be only of 10″30‴ or of 9″, as Sir Isaac Newton did sometimes suppose: And if we reckon the apparent Semidiameter of the Sun to be of 16′10″: Then, the Semidiameter of the Moon apparent to the Sun would result to Sir Isaac Newton of 2″,24. And this being substracted from 16′10″; there would remain 16′7″,26 for the Breadth of the Zone

Zone of the Moon inlightened directly by the Limb of the Sun, over and above the Moon's Hemisphere.

9. And to this Breadth adding 1' 16" for the additional Zone inlightened upon account of the Refraction of Light in the Atmosphere of the Moon, we shall have 90° 17' 13",26 for the whole Zone inlightened by the Sun, and measured in any great Circle of the Moon, situate in a Plane passing thro' her Center and the Center of the Sun.

10. At the Time of the Moon's Quadrature, any Astronomers provided with proper Instruments, may observe most nicely the apparent Diameter of the Moon, and the Breadth of her enlightned Part, when it seems terminated by a right Line. And by that means they may satisfie themselves also, about the Quantity of the Refraction of Light in ye Moon's Atmosphere.

11. And at the same Time, they may make also the necessary Observations for determining accurately the Moment when the Distance, betwixt the Centers of the Sun and of the Moon, appears to be of Ninety Degrees.

12. And likewise, with good Telescopes, having a Bit of raw Silk or small Silver-wire stretched in the Focus, and passing thro' the Axis of the Telescope, they may determine, as nicely as possible, the Moment when the inlightened Part of the Moon seems terminated by a right Line. For if the raw Silk &c. did not pass thro' the Axis of the Eye-glass, which I suppose to be convex; that Silk and the rectilinear Section of the Moon would appear curvilinear, with their Convexity turned toward the Axis of the Eye-glass.

13. Now, according to Sir Isaac Newton, the Time between those two Moments will be but small, and will not amount to half an Hour.

14. But, according to my Demonstrations, That very same variable Time will amount to about four Hours and perhaps three quarters. A Difference easily observable even by Persons unacquainted with Astronomy, but helped with a common Ephemeris of the Motions of the Moon. And thus I appeal to the Heavens and to Mankind, that is, to proper and faithful Observations of this sort, for a clear and sensible Decision of the Controversy, between

Sir

Sir Isaac Newton or his Followers; and me; concerning the Sun's Parallax. For Astronomers have wholly neglected to observe those most important Moments, when the Section of Moon appears straight. (Gent. Mag. 1738. p. 95.)

N. Facio.

Worcester
Jan. 21. 1738.

Mr. URBAN,

From Gents Mag. p. 305. 1738. 1. Mr. Dougharty senior and my self tried yesterday, being the 15th Day of May 1738, whether we cou'd determine the Sun's Parallax, by observing the Moment of the Moon's Dichotomy in her first Quarter. We made use of a Telescope, whose Object-Glass had 15 1/3 Feet to its Focus, and of many shorter Telescopes. But we found that no such Observation could be made in the Day Time, in the open Air. And so we were obliged to wait for the Night, tho' the Astronomical Quadrature happened at about five in the Afternoon.

2. But contrary to my Expectation, Mr Dougharty saw, both at seven o' Clock and at nine o' Clock, the Section of the Moon perfectly straight, by that long Telescope having two parallel Bits of raw-Silk stretched in the Focus. And with him Mr Allut also saw it perfectly straight at nine o' Clock. And as for me, I saw, with a Telescope of four or five Inches, the Section of the Moon rather concave or straight, or but very little convex, as long as some Houses did not hide the Moon from me; that is, till a quarter of an Hour after Midnight.

3. I had indeed said to them both (according to my Discourse printed in your Magazine p. ~~81~~ 208, wherein No 14 I appeal to proper and faith-

faithful Observations of this Sort) that if the Observations did declare in favour of Sir Isaac Newton, and against me, I must submit, since I do not desire ~~that~~ that any System, but Truth alone, may prevail. And if the like Observations have been made at London, or any where else, I doubt not but I shall be deemed already self-condemned, and very obstinate, if I go on to defend my own System.

4. However, since I look sincerely for Truth; and it seems most improbable that any Objections can invalidate what I have so clearly demonstrated I beg leave to examine here, whether those Worcester Observations have that Strength against me, which they seem to have.

5. And first of all, it is plain that if they are able to overthrow my System, that of Sir Isaac Newton must likewise fall; since the Moon's Dichotomy did evidently follow, and not precede, the Time of the Moon's Quadrature. But if this Objection against Sir Isaac Newton can be answered; I may justly suppose, that the like Objection against me can be answered also.

6. I have appealed to the Dichotomys in general And it is by Chance only, or for Conveniency Sake, that those Worcester Observations have been made at any Time of the first Quarter of the Moon. Therefore I may justly require, that accurate Observations of Dichotomys be made indifferently, at the Time of the first and of the last Quarter: And this, by observing also the apparent Diameter of the Moon, and the apparent Breadth of her enlightned Part. For these are the first Grounds which we may build upon.

7. As, in the first Quarter of the Moon, her Section was seen as it were straight, two Hours or four Hours after the Quadrature, as it is set down in the Ephemeris: So, in the last Quarter of the Moon, we

we may expect to see her Section as it were straight, in the like Cases, two or three or four Hours before the Quadrature in the Ephemeris. And if it shall happen that we do so, this Circumstance will as much favour me against Sir Isaac Newton, as the Worcester Observations do favour him against me. Now, this shall be the Decision for which I would be understood to have appealed to the Heavens. Namely, If the Observations of Dichotomys happening in the last Quarter of the Moon, do seem as favourable to Sir Isaac Newton, as do those Observations of the Dichotomy observed at Worcester in the first Quarter of the Moon: Then I see not how to reconcile those Observations with my Demonstrations, or with my System, except it be done as I may perhaps hereafter declare. But if the Observations of Dichotomys happening in the last Quarter of the Moon shew us the Section of the Moon ~~[illegible]~~ as continuing sensibly straight, for about two Hours or four Hours before the Quadrature: Then I see not what can be said, to justify the common System followed by Sir Isaac Newton.

8. I shall not oppose or answer any Persons that will pronounce against me, from Observations of Dichotomys happening in the first Quarter of the Moon. But, for my part, I intend to wait patiently, till we be provided with proper Observations of Dichotomys happening in her last Quarter, as well as in the first. Gent. (Mag. 1738. p. 305.)

N. Facio, Duillier.

Worcester,
May 16. 1738.

From Gents Mag. p. 352. 1738.

The Moon's Dichotomy observed the 15th of May 1738. Dichotomys overthrow the Newtonian System: And establish the very long oval Figure of the Moon.

1. I THINK it proper to add ~~something~~ somewhat more, to what I have said already concerning the Moon's Dichotomys, and the Determination of the Sun's Parallax by them.

2. I say then that the Utility and Exactness of this Method is partly obvious in the Dichotomys of Venus and of Mercury. For if one Dichotomy of Venus were observed, when the Center of the Circle, that terminates her inlightned Part, appears at 48 Degrees Distance from the Center of the Sun, we might conclude, that, As the Radius, is to the Secant of 48 Degrees, or as 100, is to 149½: So was the Distance of the Center of that Circle in Venus from the Observator at the Time of that Dichotomy, to the Distance of the Center of the Sun from him at the same Time.

3. Likewise if one Dichotomy of Mercury were observed, when the Center of the Circle, that terminates his inlightned Parts, appears at 28 Degrees Distance from the Center of the Sun, we might conclude, that As the Radius, is to the Secant of 28 Degrees, or as 100 is to 113¼: So was the Distance of the Center of that Circle in Mercury from the Observator at the Time of that Dichotomy, to the Distance at which the Center of the Sun was then from him. We might argue in the same manner, concerning the Dichotomys of Comets.

continued on p. 217.

On the im=
provement
of Telescopes
See p. 70 to 80.

At p. 70. is an account of Dollond's improvement of Refracting Telescopes. In the Philosophical Transactions for 1765. is a farther accout of improvements therein by Mr Dollond, the Son, and describes one whose compound object glass consists of two convex lenses of crown glass, and a concabe lense of white flint glass placed between them, having their common focus 3½ feet distance, bearing an aperture of 3½ inches, and magnifying with distinctness and clearness 150 times; i.e. as much nearly as a good telescope, of the common sort, of 40 feet. As Mr Dollond has not given the radii of the curvature of these glass, tis supposed that he hit upon this construction by mere practical trials, and may not therefore given them the proper dimentions to produce the greatest & best effect. — It is shewn in the Hist: of the Royal Acad. of Sciences at Paris, for the year 1764. by M. D'Alembert, from calculations, that that an equal effect may be produced by an object=-glass compounded of a meniscus of ~~flint glass~~ crown glass, a convex lens of the same matter, with a meniscus of flint glass interposed. Also in one of M. D'Alembert's proposed compound object-glasses, the aberration arising from the spherical figure is not greater than in a reflecting telescope of the same magnify=ing power; and that the aberration of refrangibility is reduced to an hundreth part of that produced by a single convex lens of crown glass of the same focal length; and that even this small quantity may be made to disappear by certain methods, which he proposes to communicate in a subsequent Memoir.

The Moon hath an Atmosphere.

In the History of the Royal Academy of Sciences at Paris, for the Year 1764. M. du Sejour says,

It appears evident to him, from the most accurate observations made on the eclipse of the sun, on the 1st of April 1764, that the solar rays, in passing by the edge or limb of the moon, suffer an inflexion, which he supposes to be equal to four seconds and two thirds. He undertakes to enquire whether this inflexion is to be attributed to the Newtonian attraction, or to a refracting medium surrounding the moon? and to shew, by calculations of the velocity of light and of the quantity of matter in the moon, that, on the first of these suppositions, the curve, described by a ray passing by the limb of the moon, can differ only insensibly from a ~~straight~~ strait line; consequently, that this phenomenon cannot possibly be owing to the first of these two causes, and that therefore we ought to conclude that the moon is surrounded by an atmosphere.

4. It is true that because the *Phases* of *Venus* and of *Mercury* change but slowly, and also because their apparent Diameters are but small; those Conclusions may not be depended upon, as if they were nice and altogether certain. The same thing may be said of proper Observations of the *Phases* of *Mars*.

5. But, in ye Observations of the Dichotomys of the Moon, the Case is not so. For the apparent Diameter of the Moon exceeds commonly half a Degree; and may be still vastly increased, by means of Telescopes. And on the other hand, the Synodic Revolution of the Moon is so quick, as not to amount to thirty Days: Which Swiftness enables us to determine more nicely the Time of her Dichotomys. Nay the Sun's very small Parallax, in reference to the Planets of *Saturn* and *Jupiter*, might in like manner be determined from those Globes, by the Dichotomys of their outermost Satellites, or of some Comets passing near them.

6. The greatest possible Distance of the Moon from us, at the Time of her Dichotomy affords so considerable a Basis, not to mention the Encouragement which my former Discourses give us; that I hope that, even here at *Worcester*, the very great Parallax of the Sun may be verified in a few Years, by Dichotomys observed with proper Telescopes.

7. Mr *Dougharty* Senior observed the Section of the Moon on the 15th of this Month of

of May, with two Telescopes having some Bits of raw-Silk stretched in the Focus: And saw that Section straight in the Main, without the least visible Alteration, from seven at night, till about half an Hour past ten; being then forced to leave off. The longest Telescope was of fifteen Feet four Inches Focus, the shortest of about six Feet.

8. And so the Section appeared straight, for about 3½ Hours: And how much longer before and after those Times is left uncertain. For, because of the great Light of the Day, the Observations that were made sooner, being too dubious, were not to be trusted.

9. Mr John Allut was with Mr Dougharty at nine o'Clock, and saw then the Section perfectly straight in the Main, by the longest Telescope. And neverthelefs Mr Dougharty has calculated that the Quadrature happened at Worcester, according to Street's Astron. Carol. at four Hours 50 Minutes, P.M.

10. If the Body of the Moon were Spherical, the Dichotomy in the Moon's first Quarter, ought evidently to appear before the Quadrature; and that, by above a Quarter of an Hour, according to Sir Isaac, ~~[illegible]~~ or by even four Hours at least before it, according to my Calculation. Therefore those Observations made at Worcester, so long after the Quadrature, demonstrate plainly that the Body of the Moon is far from being Sphe-rical.

11. Sir Isaac Newton says, Princ. p. 471, Cum mare nostrum vi lunæ attollatur ad pedes 8 3/5, fluidum lunare vi terræ attolli deberet ad pedes 93. eaque de causa figura lunæ sphærois esset,

cujus

cujus maxima diameter producta transiret per centrum terræ, & superaret diametros perpendiculares excessu pedum 186. Talem igitur figuram luna affectat, eamque sub initio induere debuit.

12. Here I cannot agree with Sir Isaac Newton. For, not to mention at present what I cannot approve of in his Theory of Tides, he forgets here the Centrifugal Force, which the monthly Revolution of the Moon would produce in her fluid Body, for instance, her monthly Revolution about the second Focus in a Stereographic Orbit.

13. That Centrifugal Force is very great: And, in the parts farthermost from the second Focus, it is greater than in the next Parts to it, in the Proportion of the Distance of that Focus from those parts; which Proportion may very much exceed that of 214 to 216; the Centrifugal Force of her Center being rated at 215. Now the Centrifugal Force of her Center is so great, as to counterballance the Fall of her Body toward the main Focus.

14. The mean Semidiameter of the Earth is to Sir Isaac Newton of 19615800 Paris Feet. And according to him, As 365, is to 100; so is that Semidiameter, to the Semidiameter of the Moon, supposing her to be Spherical, So the Moon's Semidiameter would be of 5374191 Feet. But I reckon it to be greater.

15. In a Stereographic Orbit, that great Mass of the Moon will naturally affect to have its long Axis turned toward the second Focus. For while that Mass makes half a Revolu-

Revolution about it, and that so quickly as in half a Month's Time; *it* revolves equally about its own Axis nearly perpendicular to the Plane of the Moon's Orbit, and has all ye while one and the same *Vertex* of the Spheroid, *turned* sensibly, or at least nearly, towards the second Focus: Because the Time is too short for the unequal and oblique Attraction of the Spheroid towards the Earth to act much upon *that Mass*, especially if *it* differs but little from a Sphere, or if the Sun's Parallax be very small, or if the Moon describes an *Anti-Stereographic Orbit*. And it is well known that the Areas described about the main Focus, in an Orbit nearly Circular, are sensibly proportional to the Angles described about the second Focus.

16. Besides, if there be an Ocean or any *vast Sea*, in any Part of the Moon, its too great Ebbing and Flowing would be best moderated, by the aforesaid Position of the *Axis* of the Spheroid, *directed* towards the second Focus, especially when this Focus is not far from the Line, that joins the Centers of the Moon and of the Earth.

17. Now let us consider how the Dichotomys ought to appear in that Spheroid, and likewise in a Sphere, about the Times of the Quadratures, in the first and in the last Quarter of the Moon.

18. In a Stereographic Orbit, in the first Quarter of the Moon, the Dichotomy of the Sphere precedes the Quadrature of the Sphere about the third Part of an Hour, according to Sir *Isaac*, and even by four Hours at least, according to my Demonstrations. And the Dichotomy of the Spheroid precedes still a longer Time the Quadrature.

19. When the Dichotomy was observed at *Worcester*, the Moon's ascendent Node was in 24° 33' of *Leo*: The Sun's Place in 5° 14' of *Gemini*, having yet a few Degrees above sign to reach his own Apogee

Apogee. The Moon's Place was about 4° 30' of *Virgo*. The Moon was going from her Apogee to her Perigee; which were not very far from being in Quadrature with the Sun. So the Center of the Moon's Orbit was between the Earth and the Sun; far from being in Opposition to the Sun, as it is always in a Stereographic Orbit. Upon which Account those *Worcester* Observations, tho' they proved as favourable to me as I could wish, yet do favour me much less, than other *Observations* of Dichotomys *to be made* hereafter will do. But they do already overthrow the common System, and with it the too obtuse *Figure*, which Sir *Isaac* ascribes to the Moon. For he makes *its* longer Axis to be but of 5374204 Feet, and the shorter ones to be of 5374098 Feet. See *Prop*. 38. *Lib*. iii.

20. But first of all, let us examine particularly what would happen in a Stereographic Orbit. Therein (according to the Theory and System of Sir *Isaac Newton*; P. 430 *and* 462) when the Extentricity is the least of all, the Distance of the Center of the Earth from the Center of the ~~Moon~~ *Circular Orbit* of the Moon may be supposed of 433, 227 Parts, *its* Radius being of 10000: And the Distance of the Center of the Earth from the Focus of the Orbit of the Moon may be supposed of 41, 964 Parts. The Sum amounts to 475, 191 Parts, for the Distance betwixt y^e Center of the Orbit and the *Focus*, about which equal Areas are ~~dea~~ *scrib.*

scribed in equal Times, by the Line which joins the Centers of the Moon and of the Earth. And that Number being doubled, and from the Sum substracting 41,964, we have 900,417 for the Distance betwixt the Center of the Earth and the Orbit's second Focus, about which the Angles described by the Center of the Moon are sensibly equal in equal Times. And, supposing that the Axis of the Moon's Spheroid be turned directly toward the second Focus, I find that the said Axis would make an Angle of 5° 11′ 44″ with the Line drawn from the Center of the Earth to the Center of the Moon, at the Moment of her first or of her last Quadrature.

21. And likewise when the Excentricity is the greatest of all, I find that the same Line would make with the Axis of the Spheroid an Angle of 7° 51′ 36″, viz, keeping still the same Number 41,964 as does Sir Isaac Newton. Tho', if we would make his Numbers consistent with one another, we ought rather to write $42\frac{2}{3}$ for the Winter Stereographic Orbit: Which would increase a little that Angle.

22. Now let us suppose that, at the Instant of a Geocentric Quadrature of the Moon, the Center of her Orbit be in Conjuction with the Sun; Which may happen both in the Moon's Apogee and in her Perigee, and is a Disposition the most contrary to that which results from a Stereographic Orbit. And therefore that Disposition of the Orbit of the Moon may be called an Anti-Stereographic Orbit.

23. I say then that in an Anti-Stereographic Orbit, if the Center of the Orbit of the Moon, at the Moment of her Geocentric Quadrature, b. h.

be in its greatest Excentricity, the Distance betwixt the Center of the Earth and the second Focus of the Moon's circular Orbit would be according to Sir Isaac Newton of 1293,582 Parts. But that Distance would be, according to him, of 824,490 Parts; if that Center be in its smallest Excentricity. Thus it appears, nearly, how much the Axis of the Moon's Spheroid would be turned from the Center of the Earth toward the Sun.

24. And so, in an Antistereographic Orbit, the Dichotomy must needs appear long after the first Quadrature, N.B. as it also did in the Worcester Observations. But the second Quadrature must appear a long Time after the y^e Dichotomy. Now these very long Intervals of Time are the very reverse of what happens in a Stereographic Orbit: For in it the Dichotomy must needs precede long the first Quadrature, and come long after the second. And here is a Touchstone to try our Systems by.

25. Hence it appears that many great Astronomers have been too hasty, in publishing as Matter of Fact the Phenomena of Dichotomys, not as they might have found them, by compleat and accurate Observations, but as they did guess them to be, by trusting too much to their Reasoning upon an erroneous and deficient System. However, the Moon observed with the best Telescopes, after it had past the Quadratures, appeared bisected, as Riccioli does candidly own in his Almagest, p. 734. See D^r Keill's Astronomical Lectures, p. 263.

26.

26. But there is a midling Sort of Orbits and Dichotomys, which deserve our most particular Attention; namely, those that occur, when the Moon, being in her Quadrature, is also in her Apogee or Perigee. For then, the Section, terminating the Light in the Moon's oval Body and made by a Plane parallel to its longest Axis, may be exactly or nearly directed towards the Observator; and the Parallax of the Sun may be easily deduced from the Observation itself, even as if the Body of the Moon were Spherical. And such an Observation, tho' but a single one, will be without Exception, and altogether decisive. Thus having by it ascertained the Sun's Parallax, or else only determined it by our own Methods and Demonstrations, the Case being more simple, we may best, once for all, calculate a priori, by Means of that Sort of Orbits, the Proportion of the longest Axis of the Moon to her shorter ones. And that Proportion may likewise be determined, by means of a sufficient Number of promiscuous Observations of Dichotomys.

27. Astronomers have no great Privilege, above any other Persons, to make accurate and decisive Observations of Dichotomys of the Moon. And whereas disinterested Judges of this Controversy can never be too numerous, I desire all sincere Lovers of Truth, who would satisfy themselves, and promote the true Knowledge of the System of the World (wherein Astronomy and Navigation, &c. are so much concerned) to be provided, in any Country whatsoever, with a proper Telescope, easily manageable at a Window, suppose a Telescope of one Foot, or of about ~~of~~ six or seven or eight Feet, having a very broad ocular Glass, and a proportionable Tube, and in the Focus one Bit, or two or three parallel Bits of stretch

stretched raw-Silk: And with it to observe long and fully the Dichotomys at any Time of the Year; and even to publish or declare openly their Dates, and what Hours and Minutes they were observed to begin or to end, till the Truth be known: For this will be sufficient to manifest in favour of which System it is that those Dichotomys decide. As to the Hour of the Day, it is easy to have it sufficiently known; nor is, in this, any great Nicety required, if we be concerned only about the Sun's Parallax.

28. But in reference to Eclipses, and more particularly those of fixed Stars, we can never be too nice, when we would find the Longitude by them, or discover the Length of the Moon's Spheroid. For the great Length of that Spheroid requires a new and hitherto deeply concealed Equation, which ought not to be neglected hereafter.

29. And therefore Astronomers provided with excellent Micrometers may make their Observations still more instructive; and may probably plainly perceive, in some Quadratures, and when the full Moon happens to be in a midling Orbit, that the apparent Diameter of the Moon from West, to East is longer, than the Diameter perpendicular to it. (Gent. Mag. 1738. p. 352 &c.)

N. Facio, Duillier.

Worcester
May 17 & seqq. 1738.

From Gent's Mag. p. 481. 1738.

Mr FATIO's Answer to the Objections made to him, drawn from the supposed Smallness of the Parallax of Mars.

1. LET us examine, Whether that Great and seeming unanswerable Objection, taken from the Observations of Mars (whose Parallax was found, by Mr Pound and Dr Halley, to amount scarcely to 30 Seconds) may not also confirm invincibly my Theory, and contribute to a further Advancement of Astronomical Knowledge? See Keill's Lect. p. 266, 343: Where he concludes from those Observations, That the Parallax of the Sun is scarce eleven Seconds.

Now, The Answer to that Objection may be found, partly, in the Uncertainty of the Distance of Mars from the Earth (at the Time of those Observations) in respect to the Distance of the Sun: But it must be found, chiefly, in the great Influence of the Situation of G, the common Center of Gravity of the Earth and of the Moon, upon those, or rather upon many the like Observations. And by them, and the Knowledge of the Sun's Parallax, the Situation of that common Center of Gravity may be determined: As it may be found by several other Means also, and particularly by accurate Observations of the Sun; or, likewise of the Moon. And when that is done, the true Excentricity of the Orb of Mars may be established: And the Certainty or Uncertainty of any former Conclusions drawn from the Parallax of Mars, or concerning his Excentricity, may be verified. But as I have not the particular Observations of both the said Great Astronomers, I cannot compare them now with my Theory. However, in order to shew that they may very well agree with it, I shall make

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the following Reflections, and settle this Part of my Theory as follows, by an Example fitted to their Observations.

2. Let the Parallax of the Sun in reference to the Orbit of the Moon be supposed of 2° 24′, in the Sun's Apogee, according to my Theory. And let the Distance betwixt the Centers of the Moon and of the Earth be supposed of 64 mean Semidiameters of the Earth. Then dividing 2° 24′ by 64, we shall have 135″ for the Parallax of the Sun in reference to the Globe of the Earth, the Sun being in is Apogee. And, according to the common System, supposing the Center of Mars in Opposition to the Sun to have been then about 2,781 Times nearer to the Center of the Earth, than to the Center of the Sun; the Parallax of Mars might have been of 375″,4 at most, in reference to the Globe of the Earth; and of 294″ at most, in reference to the Latitude or Parallel of the Observators. Let this last Number 294″ be called X.

3. Now supposing G, the common Center of Gravity of the Moon and of the Earth, to have been placed then at the Distance Z (from the Center of the Earth) of 2, or $1\frac{1}{2}$, $1\frac{1}{4}$, 1, $\frac{1}{2}$, $\frac{1}{5}$, $\frac{1}{10}$, $\frac{1}{20}$ Semidiameter of the Earth: That Distance Z seen from the Center of Mars would have subtended at most an Angle TMG = Z.

So we have Z = 751″, or 563″, 469″, 375″, 188″, 94″, 38″, 19″ respectively. And the Proportion given by Sir Isaac Newton (p. 469.) for determining in the Situation of the Point G, would have made that Angle Z of 589″, neglecting the

the Moon's Excentricity.

4. But that Distance Z, seen from the Center of Mars, must have subtended an Angle smaller than Z, in the Proportion, nearly, of the Radius, to the Sine of the Angle made at the Center of the Earth, by the Lines drawn from thence to the Centers of the Moon and Mars. And so their arises a proportionable Uncertainty or Parallax in the apparent Place of the Center of Mars, as seen from the Center of the Earth, and from G the common Center of Gravity of the Earth and of the Moon: Which Point G describes the Great Orb. And that Uncertainty might amount on one Side of Mars to the whole Number Z, and to as much on the other Side; if the Moon were in or near her Quadrature with Mars.

5. And therefore, if those two Great Astronomers will be pleased to renew their Calculations upon this Foot, and will have a due Regard to their own Latitude, and to the Hours of the Night (or to the Hours of the Day, if they will hereafter find the Parallax of Venus; for she may be observed in the Day-time:) They may derive from these their Observations the Situation of G the common Center of Gravity of the Moon and of the Earth, and verify that my Theory is wholly consistent with their Observations. But as long as the Situation of the Center G is unknown, or neglected by them; their Conclusions about the Parallax of Mars, and of the Sun, are most probably greatly erroneous. And so I appeal from their former Conclusions to themselves; or to any Astronomers who, knowing the Circumstances wherein those Observations are or were made, will try my Theory by them. But at the same Time

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let a due Regard be had to the Moon's Excentricity. Nay, I appeal to Multitudes of Observations of Mars, made or to be made when he was or will be nearly in Opposition to the Sun, in several different Ages of the Moon. For the Sun's Parallaxes derived in like Manner from them, especially about the Two Quadratures of Mars with the Moon, will be found widely different from one another, If the Situation of the Point G. be neglected; And if it be taken, for instance, from Sir Isaac Newton.

6. And if they shall find, or if any Astronomers or myself shall find (when we know the Days and Hours when those aforesaid Observations were made) That so ~~very~~ great a Parallax of Mars (viz. of 375" or 6' 15") is consistent with the said Observations; What must be then concluded, but, that my Theory (demonstrated, confirmed, and tried, already, by so many different Ways, and which will be further tried and confirmed, by this unexpected and critical Trial, or by Multitudes of former or future Observations of Mars or of Venus, and by many other Ways more) can not be false; but must necessarily be true. Gent. Mag. 1738. p. 484.

From Gent. Mag. p. 525. 1738.

7. As to the common Center of Gravity of the Earth and of the Moon (beside what we can do barely by Demonstration and reasoning upon some Astronomical Data) we may find also by ~~some~~ immediate Observations, in what Proportion it divides the Line that joins the Centers of those two Globes or Spheroids. And this does only require, for instance, some most accurate Observations of the Meridian Altitudes of the Sun, in and about the Times of the Solstices: And that a just Regard be had to the Situation of the

Moon

Moon at the Times of those Observations. For, beside what may be done in high Buildings fitted for this Purpose, Nature itself offers in our high Hills and Mountains, here and beyond Sea, abundance of Places where we may observe most nicely, with Object-Glasses of a distant Focus, the least Variations in those Meridian Altitudes, or in the Passages of the Sun near some other Parts of the Tropic. And the Gentleman's Magazine of May last, p. 264, mentions one Hill in Staffordshire very fit for this Purpose, beside that Use which Mr. Brooks proposes to be made of it.

8. No Man can have a greater Esteem for the transcendent Knowledge of Sir Isaac Newton, and for the vast Discoveries which he has made in the Mathematicks and in Astronomy, than I have myself. And I do build in great measure upon the sound Part of his Book. But if he was not infallible; if he was sometimes greatly mistaken, and even in the System and Divine Frame of this World: Must every Discovery, tho' never so remarkable and useful, be run down, which rectifies any of his Mistakes? See what he says in his Preface 1686 (printed again in 1726 under his Direction) when he had just been speaking of the Theory of the Moon; Ut omnia candide legantur, & defectus in materia tam difficili non tam reprehendantur, quam novis lectorum conatibus investigentur, & benigne suppleantur, enixe rogo. Admirably said, Great and Sincere Man! Were he but alive, I would chuse no other Judge than himself. For I have, nay others have often tried that he would readily own and correct any of his Oversights or Mistakes: And I know that he would have perceived and owned, at first Sight, the Soundness of my Demonstrations. I might justly claim the same

(continued on p. 232.) Indul-

Indulgence, but I do ~~not~~ strive to want it; knowing that it would not easily be granted me.

9. But while some Astronomers or Mathematicians will defend Sir Isaac Newton's or their own System, at any Rate, I do most humbly request that they would publish their Answer to those Discourses which I have already caused to be ~~made~~ printed; were it only by shewing my Errors. Or at least that they be pleased to justify Sir Isaac Newton, where my Discourses shew that he has erred; beginning, if they will, with a satisfactory Answer, to this Objection chosen among many more.

How could Sir Isaac Newton, in his 25th and 26th Propositions, make the Radius of the Orbit of the Moon Exponent of the considerable Gravity of the Moon toward the Earth, and at the same Time make the very Distance of the Moon from the Sun Exponent of the much smaller Gravity of the Moon toward the Sun? And how could he reason AT ONCE, safely, and that in different Places of his Book, upon those two most inconsistent Suppositions?

10. As I may not possibly pretend to overcome all the Difficulties, and to foresee and answer all the Questions and Objections that may occur in and against my System of the World: So it would be unjust to require those very Things from me, rather than from any other Astronomer, who can object nothing to my Demonstrations, or who may be persuaded of their Soundness. But this Discourse continues to shew how I have overcome and answered many of those Objections and Difficultys. And I intend shortly to answer, as far as I am able

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at present, the Objection taken from the Theory of Comets. I hope that, in so difficult and abstruse a Work, it will be sufficient to have done thus much for my Share, and for an Encouragement to others, especially to those Persons, whose peculiar Business is Astronomy, That they may not stand barely as unconcerned Spectators of what I may possibly do: But that they may become active, and may shew what they can do for their Share, in so important a Case.

11. In the Calculations of the Places of Venus, Mars, Mercury, the Sun, and even of Jupiter and Saturn, a Column ought to be inserted of the Motions and Place of the Moon: And the Effect of the Situation or oblique Position of the Line TG must be considered: And proper Astronomical Tables must be constructed accordingly. And if any such Tables are already constructed or published; Their Use must be rectified, by determining duly the Proportion between TL and TG; and by making use of the true Parallax of the Sun. For by this means we shall avoid, in the apparent Places of the Sun, of Venus and of Mars, some Errors, which might often amount to a considerable Number of Minutes; as it appears by this Discourse. (Gent. Mag. 1738. p. 525.)

Worcester, July 6. 1738. N. Facio, Duillier.

Mr. URBAN,

Solar eclipses not proper for determining the Longitude of places upon the earth.

I shall endeavour to shew that solar eclipses, tho' recommended for ascertaining longitude, upon examination, will be found very erroneous, though the times be taken with the greatest exactness. It may not be improper to consider, what are the requisites proper for this purpose viz. that the beginnings and endings of observations made for this purpose, be seen in the same moment of time in all places where visible. Examine this in a solar eclipse; suppose the sun totally eclipsed, and upon the same meridian in a different degree of latitude, it may be beheld but just barely eclipsed, so that the beginning and end is but a few minutes, likewise on the same meridian (to wit in the intermediate spaces between the two places) the quantity of the eclipse will be very different, and consequently the beginnings and endings of the eclipse as different and variable in time, that is, in the places where the eclipse is total it is seen to begin first, and end last, and in the other case, the beginning will be later and the end sooner. This shews that solar eclipses will not be sufficient to determine the same meridian, much less any other. But in eclipses of the moon and satellites, the times of their going in, and coming out of the shadow of their primary is seen in all places where visible at the same moment of time, and therefore capable of determining the difference of meridians with great exactness. Those that have a correspondent observer in a different meridian, and are minded to make the most of a lunar eclipse, may take the times of the beginning and end, and (if total) the beginning and end of total darkness, also the times of the shadow passing over the principal or most remarkable spot. (Gents. Mag. Oct. p. 472.) J. R

Mr. URBAN,

The same refuted.

By attempting to prove that longitudes deduced from observations of solar eclipses 'will be very erroneous though the times be taken with the greatest exactness,' J. R. has shewn that he is ignorant of the method of determining the longitudes of places from such observations. It is not, as his objection supposes, by immediately comparing the observations at one place, with those at another, but the time of the true conjunction at each place is deduced from the observations at that place, and from the difference of the times thus deducted, the difference of the meridians of the places of observation is inferred. Now this method is so far from being very erroneous, that, in the opinion of the ablest astronomers, it is at least as accurate, as any we have. (Gents Mag. Nov. p. 522.) W.

Suppose a Quadrant (see ~~page~~ the Margin on p. 159) 70 Inches, the Radius of the exterior circle or limb, divided into every five Minutes and this distance again subdivided into every five seconds by Diagonal lines, and 60 concentric circles, equally distant from each other, ,083 Inch, whereby the whole breadth of the limb will be 5 Inches. N. B. This is as near the Dimentions and divisions of Mr. Jones Quadrant as I can guess to the best of my memory. From which I make the following calculation, according to what is said on p. 159.

Rad. : CE = 65 Inches — 1,8129134
: S. ∠ACB = 5' ——— $\bar{7}$,1626960
: EF = ,09453865 — $\bar{8}$,9756094

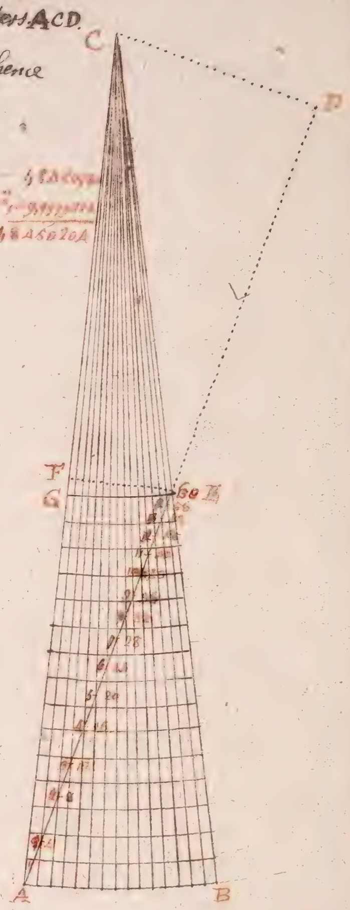
,0000011 = Nat. Vers. ACD.
65 = CG.
,0000715 = FG, thence
5,0 = AG
5,0000715 = AF

As AF = 5,0000715 Co Ar. $\bar{9}$,3010230
: Rad. :: FE = ,09453865 — $\bar{8}$,9756094
: Tang. ∠FAE = 1°. 4'. 59",5 — $\bar{8}$,2766324
whose Compl. = ACD = 88°. 55'. 00",5.

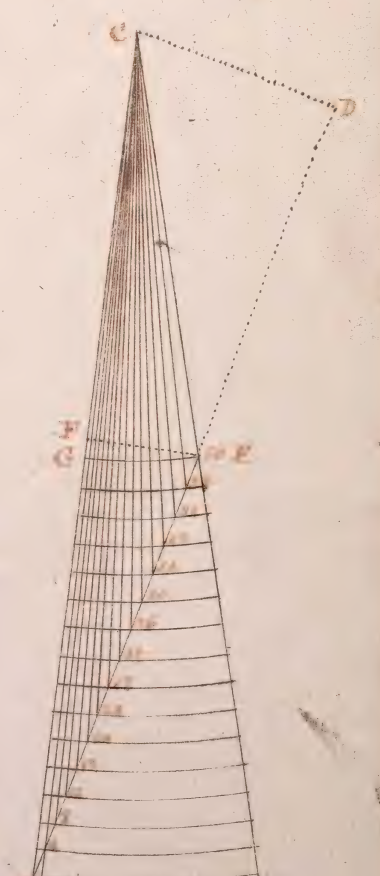
Rad : AC = 70 Inch — 1,84[illegible]
:: S. ACD = 88. 55. 00 — 9,999[illegible]
: AD = 69,9874[illegible] — 1,8450204

Rad. : AC = 70 Inches — 1,8450980
:: S. ∠FAE = 1°. 4'. 59",5 $\bar{8}$,2765575
: CD = 1,323292 —— 0,1216555

60)5,00 ~~[illegible]~~ = AG
,083 = A1 = distance of each concentric circle.



No. of equidist. conc. circles from A	Their Radii in Inches	Their angular distance from AC, at the intersection with the diagonal AE by Calculation		
AB	70.	0. 00. 00	0. 00. 00"	0. 00. 00
1	69,916	0. 00. 04,7	0. 00. 05	0. 00. 00,3
2	69,833			
3	69,75			
4	69,666			
5	69,583			
6	69,5			
7	69,416			
8	69,333			
9.	69,25			
10.	69,166			
11	69,083			
12	69.			
13	68,916			
14	68,833			
15	68,75			
16	68,666			
17	68,583			
18	68,5			
19	68,416			
20	68,333			
21	68,25			
22	68,166			
23	68,083			
24	68,			
25	67,916			
26	67,833			
27	67,75			
28	67,666			
29	67,583			
30	67,5			
31	67,416			
32	67,333			
33	67,25			
34	67,166			
35	67,083			
36	67,			
37	66,916			
38	66,833			
39	66,75			
40	66,666			
41	66,583			
42	66,5			
43	66,416			
44	66,333			
45	66,25			
46	66,166			
47	66,083			
48	66,			
49	65,916			
50	65,833			
51	65,75			
52	65,666			
53	65,583			
54	65,5			
55	65,416			
56	65,333			
57	65,25			



59|65,083

Curious Queries on Light and Heat.

Philosophical Queries, insinuating that light and heat are two different substances existing independantly of each other. Publish in a Mag. about the year 1764 or 1765. and which were extracted & given me by Mr. White of Corby. as follows

1. Warmth is felt in a dark place. The Light may be permitted in a place and yet the place excessive cold. A dark chamber heated by a stove will continue dark. Quere, is not here light without heat, and heat without light?

2. The moon lighteth resplendently, but not heateth. Quere?

3. The top of the Alps, peak of Teyde in the isle of Teneriff, summit of Condeleras of Peru in the heart of the Torrid Zone, is the sharpest cold with the brightest light. Is not here light without heat?

4. The Rays of the moon contracted by a focus five hundred times brighter than the full moon, warms nothing, nor raises the least motion in the Thermometer. Is not here light without heat?

5. Chrystal glass and precious stones full of light but cease being so as soon as red hot. Can this heat be light?

6. If light was heat we should have excessive heats before the solstice, as after, and in May as in July. Would not this be the case?

7. The body of light an immense fluid always about, but not always moved and vibrated as far as us. It may be vibrated, driven, by the sun, by a conflagaration, a flambeau, a spark, and all inflamed bodies; but is not the production of them. Hence undoubtedly Moses begins his account of the creation with the body of light. Is not this the case?

8. If the Lanthorn on the tower of Messina is perceived in the space of only eight cubic leagues, itself in the center, it fills the whole space. If a Lanthorn be darkened, the light disappears, but when uncovered fills the said space with new light instantly, what an immense quantity of light must be produced from this lanthorn in one night. Can this be true?

9. As the Air exists before the bell strikes it, so the light exists about the Spharos of Messina before the erecting of the Lanthorn, wanting only the action of fire to make it visible. why may not this be true?

10. As the Air forms no emanation from the bell which strikes it: why should the light from the sun or any other luminous body?

11. If light was a production of luminous bodies, the Owl and other nocturnal animals could not see in the night. The pupilla of the owl is susceptible of great dilitation, whereby its eye assembles a great quantity of that feeble light. The Cat still passes for being the rival of the ~~night~~ Owl in this faculty: as also the Mole in its subterraneous abode. Can

Can these animals be said to see by the help of luminous bodies?
12. A piece of Iron hot enough to burn casteth no light; why?

The sole end of all these queries is to determine;
1. whether Light is an emanation from luminous bodies
2. And whether Light and Heat are one and the same thing.

Thus far the Querist. ~~I find them extracted~~ I find the 9 first extracted from Nature Displayed 8.vo 1739. Vol. IV. Dialog. XI. p. 147. &c. Or in Nature Delineated 12.mo 1744. Vol. IV. Discourse XI. p. 90. To which is added, these two on fire.

Two Queries on Fire.

1. A violent fire, as lightning, and large hail-stones often proceed out of the same cloud. Can this be true?
2. Air increases fire, and yet the blast which animates the fire on the hearth would extinguish the taper: the same fan equally cools and lights our fire. Quere this?

My own considerations on Fire. see the next page. —

These drew me to consider the nature of Fire, on April 22.d 1768, which I put down as follows

It appears to me that FIRE is a substance, or a fluid per se, existing in three different states and conditions; and that Fire, Light, Heat, Air, Darkness and Cold are all one and the same thing.

I. Fire in Orb, heats burns and shines, besides many other properties of penetrating ~~into~~ between the pores of other bodies, &c.

II. When the most subtle and minutest parts are dissipated, and proceeded so far as to cause the fire to lose the properties or qualities of heating, burning and shining conjointly, I call it Fire dessenimated; which

1. Retains the property of shining, either with or without heat, and is then what I would call Light.
2. It Retains the property of heating, with or without shining, and this I call heat; making Light and heat only two different sensible qualities of Fire.

III. When this dessenimated Fire becomes so languid as just to lose the two last sensible qualities, I would call it Air dissenimated; and this hath

1. The property or quality of darkness either with or without cold. Or
2. The property or quality of Cold either with or without darkness.

IV. And when it hath obtained or acquired these two sensible qualities of darkness and cold in the most intense degree, as Fire in Orb hath those of light and heat, I would call it Air quiesent: So that Fire in Orb and Air quiesent are the two extremes of all the

the intermediate states and conditions of one and the same elementary fluid. — This contradicts Jones's opinion, p. 160, 161, 162. And Dr. Hill's in his Thoughts on GOD and Nature p. 322. to 344. See also Hillary's Laws of the motion of Fire. Dr. Desaguliers Philosophy Vol. II. p. 367 to 370. Hale's Vegetable Statics Vol. I. p. 278 to 280, also p. 287, 288 and Vol. II. p. 318. Moreover Vol. I. p 35 to 37. Dr. Desagulier's Gravesande's Philosophy in 4to Vol. I. p 63, to 95. Also on flame Vol. II. p. 87, 88. Or in the 8vo Edit. 1737. Vol. II. p. 1 to 18. Rohaulti Physica Pars III. Cap. 9. Art. 2. ad 23. et seq. — Des Cartes Philos. — Crooker's Dictionary under the word FIRE. Philos. Trans. &c. &c. — Nature Display'd, 8vo Edit. 1739. Vol. IV. Dialog. XI. p. 147. to 204. Also Vol. III. p. 210, 226, 430, 431, 432, 433. Boerhaave's Chymistery.

Other thoughts revoking the former on the subject of Fire.

Augst 30, 1769. I cannot admit my Theory of Fire, as above. I was drawn into the mistake of making it a Substance, and even a fluid per se, by others asserting it to be so: nor have I ever met with any author who expresses the least hint to the contrary. Yet I must notwithstanding deviate from them all, even from Hutchinson and all his followers; and assert that no other foundation or principle ~~of Natural Philosophy~~ ought to ~~should~~ be admitted into Natural Philosophy, than these two, Matter, and Motion, as laid down by Dr. Wilson in his excellent treatise, on the laws of Matter and material Motion. in consequence of which Fire itself is nothing but a sensible quality of certain matter put into a very rapid motion. Or ~~A less degree of Motion~~

I. This matter from the most ~~rapid~~ violent & rapid motion down to a certain ~~and~~ less degree of it, is jointly endued with the several qualities or properties of heating, burning, ~~and~~ shining, penetrating into the pores of all other bodies, (*) &c. which hath hitherto been understood as a fluid per se, and expressed by the one word Fire; but I would call it Fire in Orb. ~~As this is not the natural state of this matter, it must undergo various degrees of motion before it arrives at the swiftest, and consequently be endued with different qualities,~~ as ~~it passes from one degree of motion~~ to another; and in fact ~~we~~ find ~~this to be the case~~ from the different degrees of

(*) dissipating some, and converting ~~others~~ them into ashes; liquifying some; ~~and~~ calcining others;

Since this is not the natural state of the Matter, it must undergo various degrees of motion before it arrives at the swiftest, and as it passes from one degree of motion to another it will have different qualities, which are so many different degrees of what hath hitherto been understood by elementary Fire. And the prism discovers this to be a fact in nature by separating these different qualities or sorts of fire from each other. It shews that the least degree of motion to obtain the quality of fire will produce a violet colour; the 2nd indico; the 3rd blue; the 4th green; the 5th yellow; the 6th Orange; ~~and~~ the 7th and last red. Likewise a bright iron sufficiently heated in a smith's fire will assume all the colours of the prism, and in the regular order above; viz, ~~the first, whilst the heat motion~~ the first degree of motion acquired by the matter to produce the least degree of fire will shew itself upon the iron to be of a violet colour, or it will first communicate~~s~~ that colour to the iron, and then an indico; and so on to a red; and since they are here all blended together in the same Substance, the last or greatest degree of fire will be of a white colour.

These different colours also appear in a burning lamp or candle; at the bottom where there is the least degree of motion and heat, there will be the violet; ~~at~~ about the wick or metch where there is a much greater degree of motion and heat, there ~~is~~ the red appears, and so the intermediate ~~degrees~~ colours ensue from the intermediate degrees of motion, mutatis mutandis.

II. Just before this matter hath acquired the motion which gives it the property ~~of~~ of dissipating ~~consuming~~ some bodies, and converting them into ashes; liquifying some and calcining others ~~and liquifying others~~, called above Fire in Orb, it hath the ~~propert~~ quality or property of heating and shining jointly down from thence to certain degrees of less motion; and this I would call Fire disseminated.

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On the Effect of heat & cold upon the animal body.

The effects of heat and cold may be considered here with respect to their action on the nervous, sanguineous, and glandular systems. Dr. Falconer's remarks on the influence of Climates, &c. 4to. 1781. — Book I. Chap. I. p. 3.

On the effect of heat upon the living human body.

Heats is perhaps the most universal stimulus with which we are acquainted, when applied to any great degree to the human body, it excites the action of the nervous system in general, and of the cutaneous nerves especially, which are most exposed to its influence, and renders them more susceptable of any impression. If the heat be long continued, it produces a moisture upon the skin, called perspiration, which, by relaxing the cuticle, keeps the subjacent nervous papillæ in a supple state, and obvious to every impulse. It likewise exposes the extremities of the nerves to external impressions, by keeping the skin in a smooth state, and void of corrugation. Heat also, by increasing the secretion of perspiration, causes the perspirable matter (similar to what occurs in other increased glandular discharge, as the saliva, the mucus of the nose, &c.) to be very much attenuated, and consequently fit for being easily and quickly evaporated, without the same portion of it remaining long upon the skin, or leaving much residuum; which renders the cuticle very thin and fine, and of consequence fit for transmitting sensations through its substance. By increasing the perspiration, heat diminishes the other evacuations, and even the secretions. The urine is separated but in small quantity, and the alvine evacuation is very slow. The bile however must be excepted, which is considerably increased in quantity, and as some think rendered more acrimonious in quality. The disposition of the body and juices to putrefaction is also much augmented. ibid. Chap. II. p. 4.

Effects of cold on the living human body.

Cold, on the contrary, in similar circumstances, corrugates or wrinkles the cuticle, and causes the cutaneous papillæ to contract, and to retire deeper into the skin. It also closes the orifices of the cutaneous glands, and thus prevents the access of any irritating substance. By contracting the nervous papillæ, it diminishes perspiration, and probably makes the perspirable matter more viscid, which renders the cuticle more dry and rigid, and even considerably thicker; by all which the accuracy of sensation or feeling is much diminished.(*) Perhaps too, as Mr. Montesquieu

(*) Mr. Winslow remarks, that the insensible perspiration is always greatest where the feeling is required to be most accurate, as in the palms of the hands, insides of the fingers, &c. — Winslow's Anatomy.

ob=

observes, the constriction on the miliary glands may render the nerves of the skin in a degree paralytic, and this I am inclined to believe may be in some measure the case from the insensibility which occurs in the access of fevers, especially † intermittents, where the cold fit is the most strong and distinguishable.

The secretion of the bile is diminished by cold, and its quality rendered less acrimonious. The urinary and alvine evacuations are more regular, and more proportioned to the quantity of food taken in. The bodily strength is also greater, the bulk of the body larger, and its humours less disposed to putrefaction. ibid Chap. III. p. 5.

Learning & knowledge beneficial to the intellectual faculties.

Literature seems to be to the mental capacity what cultivation is to the soil. Though it may not, perhaps, increase its absolute fertility, or give it new powers, it brings those it before possessed so much into action, and directs their application, and combines them in such a manner, as to produce nearly the same effects, which an addition to their strength and force would have done.

Learning and knowledge may therefore be presumed to be favourable to the human faculties in general, particularly to skill in the arts. ibid Book III. Chap. V. p. 481, 2.

An extraordinary Cure for Cancers. Universal Museum, Vol. III. p. 308. for 1768. Another extraordinary cure in the Gents Mag. Vol. LX. p. 1164.

A Poor woman laboured many years under a most inveterate Cancer in her breast; she applied eight toads, tied up in muslin bags, to eight holes in her breast, which sucked amazingly. — The toads fastened eagerly like leeches. — When they had sucked themselves full, they dropped off in agonies, terrible to behold. They gave no pain; but on the contrary, her pains abated from the first application. She repeated this till she had demolished 120 toads. By which time the wounds were healed, and her breast was of the usual size. She has been well ever since. — The toads were applied every night. The better she grew, the longer they lived, and the longer they sucked. A man with a Cancer in his back, & another woman, were cured in the same way.

Virtues of Sal-Ammoniac, alias Cyreniac.

Sal-ammoniac operates by urine and sweat, and is a good aperient in all kinds of obstructions. Dose from 20 grains to a dram, or more. It is a (Crude, without any preparation) Specific for vernal agues, and indeed with bitters is a good antifebrile in general for all intermittents. Nothing is better to resolve bruises. It is fit to give along with the bark to prevent the cortex causing obstructions.

Sal-ammoniac is a perfectly neutral salt, capable of attenuating viscid humours, and promoting a diaphoresis, or the urinary discharge, according to certain circumstances of the constitution, or as the patient is managed during the operation. Thus a dram dissolves

† Cullen's Practice of Physic, § XIX.

ved in water taken and the patient kept warm, it will generally prove sudorific. By moderate exercise or walking in the air, its action is determined to the kidnies. A larger dose gently loosens the belly, and still a larger proves emetic.

Externally this penetrating salt is an antiseptic; it is proper for lotions and fomentations, against gangrenes and oedematous tumours, it is good for gargarisms, for inflamations of the throat and tonsils, and for attenuating and ~~dissolving~~ discussing viscid humours. A young man was suddenly taken with a swelling in his tongue, without any apparent cause; it swelled out of his mouth to such a degree that he could neither speak nor eat, and was in danger of being choaked; a solution of Sal-ammoniac in water was ordered him and he did well by the next day. — The utility of this salt is also well know in making melted tin adhere to copper vessels, commonly called tinning them.

Virtues & Use of Cardüus Benedictus. for a Stomachic

Carduus Benedictus the blessed thistle, well worthy the title, is an annual plant, cultivated in gardens; it flowers in June & July, which is the best time for gathering it; it should be kept dry, in an airy place, to prevent moulding & rotting, which it is very apt to do. The leaves and seeds are the only parts used in pharmacy; these have a penetrating bitter taste, not very strong nor durable, attended at first with an ingrateful flavour, much of which it loses by keeping, even cold water extracts, in a few minutes, the fine light and more grateful parts of this excellent plant; but if the digestion be continued some hours, the disagreeable parts will also be extracted. Hence a strong decoction is exceeding nauceous, and even offensive to the stomach; but rectified spirits of wine gain a very pleasant bitter taste, and remains uninjured in the extract. — The nauceous decoction is sometimes used alone to provoke vomiting, and a strong infusion to promote the operation of other emetics; but this elegant bitter, when freed from the offensive parts of the herb, may be advantageously applied to other purposes. — A light infusion of clipped carduus in cold water is excellent in loss of appetite, where the stomach is injured by irregularities, and far preferable to the common compound bitters of the shops. — A strong infusion made in cold or warm water, & drank freely, and the patient be covered up warm, will produce a plentiful sweat, much safer and better, than when forced by confounded Venice treacle, and promote all glandular secretions; or dashed with white wine, it is of great service after catching cold, to restore interrupted perspiration, and set all to rights again. — A quarter or half a pint fasting, or an hour or two before dinner, or both, is good to create and appetite; or a dram made from it, to such who can bear nothing colder in their stomach: it also kills worms. — It is a proper bitter to be taken with bark, both to make it sit easier upon the stomach, and to render that drug still more efficacious. — Lesser centaury is entitled also to all we have said on the blessed thistle. — John Cook. Universal Museum Vol. III. for 1767. pp. 626.

Cure for the bite of a Mad-dog.
see p. 258.

In the case of a person bitten by a mad-dog, cuticular incissions are to be made about the place bitten, and to let them bleed till they stop of themselves; then to rub into the place bitten, and all about, mercurial ointment, and cover the sore with a mecurial plaister. At night the patient takes a bolus, with two, three or four grains of calomel, and the next morning a dose of salts, or any other gentle purgative. The morning following he must go into the cold bath.

The mercurial ointment must be rubbed in every night and morning, the mercurial plaister over it. The calomel bolus must be taken every other night, and the purgative the morning following; and the cold bath used the intermediate days. This process being pursued rigiously during a fortnight, the patient may be assured of safety, provided he has applied immediately upon receiving the bite. J. Andree. Gents Mag. 1777. p. 440.

Cure of Persons apparently drowned.

The methods generally used for the recovery of person apparently drowned are these: Dry linnen and cloaths put on as soon as possible. Bleeding in one or both arms to the amount of six or seven ounces. Frictions of common salt, upon the back, and chiefly upon the spine; and sometimes also, of gin and spirit of salt, not only along the back, but also upon the temples and breast. Blowing air into the lungs and up the fundament, and sometimes fumes of tobacco. A repetition and continuance of the above frictions. Two or three glisters given at proper intervals. And various fomentations, begun as soon as possible, and continued without interruption.

For persons weak and delicate, the smoke of dried marjoram, rosemary, mint, or other aromatic herbs, is preferred to that of tobacco; and bleeding is not to be used indiscriminately, when the body is cold or frozen. Moderate head is strongly recommended. And One was recovered by being wrapped in the warm skin of a sheet instantly killed for that purpose.

Persons have been recovered who have lain in the water 20, 30, 45, minutes; and one a full hour, half an hour more elapsed before the surgeon arrived; a full quarter of an out was taken up in removing him to a proper place; it was three hours before he shewed any signs of life, and twelve before he opened his eyes. This is sufficient to present any from too hastily giving up the hopes of success.

The following circumstances are reprobated as dangerous, holding the body up by the hells; throwing the head back during the operations, (it ought to be a little bent forward); rolling the body upon a barrel; pouring spiriteous liquors into the mouth, without being sure that the patient can swallow them; in fumigating tobacco up the anus, without emptying the rectum, and then placing the body in a right line, instead of which it ought to describe a curve; warming it by too large a fire; overloading the breast by an excessive weight; and not closing the nose and mouth when air is blown into the lungs. &c. Gent. Mag. for 1797. pp. 467, 8.

Cure for the bite of a Mad-Dog, and other venomous Animals. see p. 257.

Dr. de Moneta, Physician in ordinary to his Polish Majesty, first advises to cover the wound with fresh earth, or with snuff, to imbibe the saliva of the animal, and then to wash it with water. At the same time, warm half a pound of butter in four times as much vinegar; and when the wound is cleared, apply a compress of linen, steeped in that mixture, and moisten it very often with the same for nine days: after which time you may safely remove the compress, and cure the wound in the usual way. During the time that the vinegar is used outwardly, the patient must take it internally, four times a day, in doses of an ounce and a half of vinegar, warmed, with a little fresh butter; and his common drink, for at least fifteen days, must be pure water, with a little vinegar or juice of citron. — Any strong liquor is extremely hurtful, as is any emotion of anger, or impatience. Plethoric patients may be blooded; but this precaution the author regards as little necessary. The Doctor has used the same remedy against the bites of Vipers, and other venomous reptiles, and always with success. He has prevented the hydrophobia in more than sixty people; and many other physicians, who have followed his method, have found it equally effecacious. It is remarkable that, in Italy, vinegar has also been lately discovered to be a remedy for this dreadful disorder.

Appendix to the Crit. Review. New Arrangement. Vol. V. Sept. 1792. p. 551, 2. Under the Article Poland.

Remarks on Prob. I. p. 126. of Ludlam's Astronomical Observations made in St. John's College Cambridge, in the years 1767 & 1768. where he computes the force of the swing wheel upon the pallets of a clock.

See p. 300.

It is well known that the swing wheel of a clock would ~~[illegible]~~ urge ~~[illegible]~~ the pallets with all that force or power, which it receives from the weight, by means of the other wheels and pinions, if it acted perpendicular to the pallet; but as the ~~by reason~~ ~~of~~ the power ~~[illegible]~~ of the acting tooth ~~being~~ is exerted in a direction at right-angles to the plane of the wheel, which is inclined to ~~the plane~~ the plane of the pallet's face, ~~are inclined to each other this action~~ it will be exerted in an oblique direction on the pallet: ~~and~~ therefore will be part of it lost, and ~~part of it~~ the remainder will be communicated to the pallet itself, ~~[illegible]~~ giving it a tendency to move ~~[illegible]~~ perpendicularly to the plane of it's face: ~~the resistence it makes against the tooth in to the receiving this power from the tooth causes a pressure upon the arbor of the swing wheel and as it is not at liberty to move in a direction the perpendicular to the plane of its face, it causes a pressure also upon the arbor of the pallets.~~ but as it is not at liberty to move in this direction, it makes a resistance against the tooth, in receiving this force or power; and thereby occasions a pressure both upon the arbor of the swing-wheel, and arbor of the pallets themselves. The remaining part of ~~the~~ this power, received from the tooth of the wheel; is exerted in ~~a~~ the direction of a tangent to the circle, which the point of action endeavours to describe round the arbor of the pallets. this arbor has therefore a kind of rotary motion, which is communicated to the rod of the pendulum by means of the crutch. Hence it necessary follows. 1st That if a power be impressed upon the plane of the pallet, equal, ~~to~~ but in a contrary direction, to that which exerts itself in the aforesaid tangent; the whole movement will be sustained in equilibro, as proposed by Mr. Ludlam. 2. It is plain that whether the face of the pallet acts against the tooth, or the tooth is said to act against the face of the pallet, ~~to~~ that occasions the pressure upon the arbor of the swing wheel; yet this ~~force~~ pressure will ~~will~~ be exerted from the acting point ~~on~~ upon the pallet or tooth, to the center of the wheel, and not from the center of the wheel to the pallet: and therefore does not conspire with, but opposes the action of the tooth upon the pallet, just the same as if it was exerted in a contrary direction upon the pallet itself: ~~for~~ because it arises entirely from the resistence of the pallet alone. Wherefore that ~~part of the~~ power which is communicated to the pallet, by the action of the tooth, is evidently divided into three others, viz. one ~~at~~ upon the center ~~of the pe center~~ of the swing wheel, ~~and~~ another upon the center of the arbor of the pallet, ~~and a third~~ in a direction from the acting point to those centers; and a third, ~~which is~~ communicated to the pendulum by the crutch, in the direction of the aforesaid tangent. 3. When a power is impressed equal, but in a contrary direction, to this last mentioned power, which tends to move the pendulum, and the whole movement is in equilibro, as above expressed; it is manifest, that the power impressed upon the tooth of the swing-wheel, by the weight, counteracts, and sustains the other three; viz. ~~two upon the two arbors~~ one upon each arbor, and another supposed to be impressed upon the pallet; ~~besides~~ over and above what is lost by reason of the oblique direction. 4. ~~It~~ Hence it cannot ~~hence~~ be denied, that this power, impressed upon the tooth of the swing wheel, by the weight, is greater than the whole sum of the other three, which counteract, and keep it in equilibro. — These ~~are~~ plain, and evident matters of fact, not involved with any mathematical theory, will greatly contribute to our assistance, in the application of mathematical principles, for ~~the~~ computing ~~of~~ their respective effects: For I believe they are the standard of truth, and will bear the test of comparing and measuring whatever has been truly said on the subject; ~~when~~ in order to obtain a right judgment. Those

who are pleased to try the experiment, and trust to ~~fact~~ matters of fact, rather than ~~theory~~ the present theory of mechanics, will be convinced, that ~~what I have related~~ these truths ~~if they~~ are is sufficient to try the evidence of what Mr. Ludlam has advanced, p.126. Prob. I. of his Astronomical Observations, made at Cambridge, in the years 1767 & 1768. which is briefly as follows.

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From the Gents Mag. 1737. Vol. 7. p. 412.

The PARALLAX of the Sun deduced from Sir Isaac Newton's Principles, without making use of any Observations, or of any common Center of Gravity.

This Method is built upon the apparent Semidiameters of the Sun and of the Moon. And upon the Proportion of the Diameters of the Moon and of the Earth. And upon the supposed but erroneous Proportion of the Densities of the Sun and of the Earth. And upon the Distance of the Focus of the Orbit of the Moon from the Center of the Earth.

Fig. 50. 1. THE Radius LT, or mean Semidiameter of the Orbit of the Moon L, being made of 100 Parts, let us conceive a Globe equal to the Earth and having its Center at the Distance of 365 Parts from the Center of the Earth. And then the opposite Tangents, drawn to that Globe from the Center of the Earth, will intercept an Angle of 31′ 16″½, equal to the mean apparent Diameter of the Moon. For we may here suppose with Sir Isaac Newton p. 469, that the true Diameters of the Moon and of the Earth are to one another as 100 to 365, till their Proportion be determined much more nicely, which may certainly be done.

2. But if, from the Center of the Earth, we make the opposite Tangents, drawn to a Globe equal to the Earth, to intercept an Angle of 32′ 1″ equal to the mean apparent Diameter of the Sun, then the Center of that Globe equal to the Earth must be nearer, and at a Distance from the Center of the Earth equal to 354, 5140 Parts, or thereabout.

For

For, as 32′ 12″; is to 31′ 16″ ½; or, as 19320, is to 18765; so is 365, to 354, 5140.

3. And if, in the Region of the Moon, LH, or the mean Gravitation, or Fall of the Moon toward the Earth in 2 Minutes time be represented by 100,0000 Particles of any kind; as suppose by LH taken at discretion; or rather here by the Radius LT made of 100,0000 Parts then at that aforesaid Distance of 354, 5140 Parts from the Center of the Earth, the Gravitation toward the Earth will be represented by 10,0160.06 Particles of the same kind.

4. For as 354, 5140 Quad. is to 100,0000 Quad. so are 100,0000 Particles, or the mean Fall LH or LT of the Center of the Moon in 2 Minutes time, from her place toward the Center of the Earth, at the Distance 100,0000, to the mean Fall of a Satellite or of any heavy Body toward the Earth, which would happen in 2 Minutes time from the Distance 354, 5140; which Fall by consequence would be of 7,956667 Particles.

5. But if a Globe equal in bigness to the Earth were composed of Solar Matter, then at that Distance of 354, 5140 Parts, which of LT contains 100, the Gravitation, or the Fall in 2 Minutes toward such a Globe, would be 4 times less, and its Exponent would be of 1,989167 Particles, according to Sir Isaac Newton. For he has proved in his own way, or at least concluded, that the Density of the Sun is 4 times less than the Density of the Earth. See his 405th page. But I believe a very great Correction, or Amendment to this Assertion of his, may be expected from proper Observations, and even from my own Calculations.

6. Now whereas the apparent Diameter of the Sun is given, and his immutable Density is

in a determined or immutable Proportion to the unchangeable Density of the Earth: Therefore, if the Center of the Sun be supposed farther off from the Center of the Earth, his real Bigness and Mass must be increased, and be as the Cube of the Distance betwixt his Center and that of the Earth. (But this is a Thing, which Sir Isaac Newton seems to have overlooked.) And, by consequence (as that Great Man has demonstrated it, p. 191. Prop. 72. and as it follows also from my Theory of the Cause of Gravity) the Action of the Sun S upon the Moon, represented by HI parallel to LS, and upon the Earth, independently from any Center of Gravity, will be directly as the Distance of the Center of the Sun from the Center of the Moon, or else from the Center of the Earth T, if ye Centers of these three Globes do form an equicrural Triangle, as they will always do, at a certain Time after the Evening Quadrature, and at another Time before the Morning Quadrature. And by diminishing or increasing TS or the Distance of ye Sun, in any Proportion, the Gravitation HI towards him must diminish, or else increase in the same Proportion, even in infinitum.

7. Therefore we may say, as the aforesaid Gravitation 1,908167 toward a Globe of Solar Matter, is to the Gravitation 1 towards another the like Globe of Solar Matter, appearing under the same Angle as that which the Sun in its mean Distance from the Earth does subtend: So would be that first Distance

tance of 354, 5140 Parts, whereof L.T contains 100; to the Distance of 178, 22278 the like Parts, whose Logarithm is 2, 2509632. And this would be the Distance ST or SL, at which the Center of the Sun being placed from the Centers of the Earth and of the Moon, the Gravitation or the Fall of these Globes in 2 Minutes toward the Sun S would be expressed by one Particle, whereof L.T, or even L.H made likewise Exponent of the Gravitation or Fall of the Moon from L towards the Earth in 2 Minutes time, contains 100; when the apparent Diameter of the Sun is of 32′ 12″.

8. And if it be found that the Gravitation of the Moon toward the Sun, and by consequence of the Earth also, must be expressed by TY or HI of 2, or 3, or 4, or 5, or 6 the like Particles of the Line L.T or of the Line L.H; then TS the Distance of the Center of the Sun from the Center of the Earth must be proportionally repeated of 2 times, or 3 times, or 4 times, or 5 times, or 6 times 178, 22278 Parts, whereof L.T or L.H contains 100.

9. The Focus F is the Point toward which the Moon is drawn, in the Direction L.I FY, by the united Actions of the Sun and of the Earth. And the Line L.T being taken for Radius of 100,0 Parts, the length of the Line TF is determined by Sir Isaac Newton at about 4, 1964 Parts, whose Logarithm is 0.6228760: Neither is he contradicted in this, in Mr Robert Wright's Address printed in 1728. And this they do both of them suppose indifferently, whether the Earth be in the Perihelie, or in the Aphelie. But herein is a manifest Danger of a Mistake. For, in those 2 Sites, the Lines TY

and TY, or HI and HI, as Exponents of the Gravitation toward the Sun S, are to one another, according to the Excentricity which Sir Isaac Newton gives to the Great Orb, p. 460, as the Square of $1016\frac{11}{12}$, to the Square of $983\frac{1}{12}$, that is as 966451 to 1034419. As to the Calculations of the Place of the Moon, that Danger may be avoided, by a proper Table of Equations. But it might have a bad Influence; in the Calculations concerning the Suns Parallax,

10. Let the three Centers of the Earth, of the Sun, and of the Moon be supposed to form an equicrural Triangle: And then, from any chosen, or supposed or calculated a rallactic Angle TSL; and with it, from any Situation of the Focus F, determined either by Observations, or by Calculations made by yͤ help of the best Lunar Tables and Theories; the resulting Exponents TY and HI of the Gravitation in T, or in L and T, toward the Sun, will be found in Fact very nearly, and may afterwards be much amended. And we may calculate a Table thereof, and find, in parts of LT made equal to 100, the resulting Distance TS, betwixt the Centers of the Sun and of the Earth. And by consequence we may find the same Distance ST in Paris Feet also.

11. For, as the Exponent TF or TY made to be of one Part whereof LT contains a 100, is to TS or to the Distance betwixt the Centers of the Sun and of the Earth of 178, 222.78 the like Parts, of wch Number the Logarithm is 2, 2509632: So is the Line or Exponent TF or TY made to be, or found, by Observations or Calculations, to be of any other

Number of Parts, suppose first with Sir Isaac Newton of 4,196, &c. Parts, whose Logarithm is 0,6228760; to TS, or to the corresponding Distance between the Centers of the Sun and of the Earth, independently from any common Center of Gravity. But that common Center of Gravity shall make hereafter another Branch of our Inquiry. And so the Logarithm of the Distance TS comes out first equal to 2.8738392; and TS equal to 747,8925 Parts.

12. And as this TS, is to LT, that is in Logarithms, as 2.8738392, is to 2.000 &c. So is the Radius of the Tables, to 9,1261608. And this is the Sine of 7°.41.2½; which would be the greatest Elongation of the Center of the Moon from the Center of the Earth, as seen from the Distance ST which is betwixt the Centers of the Sun and of the Earth; supposing the Angle TLS to be changed into a right Angle; and LT to remain of 100 Parts as before.

13. Having now proceeded thus far, we may find the Length of TY as follows. Let FZ parallel to SL cut the Radius LT in Z. As ST, is to LT: So is FT, to TZ, or 100 FT, to 100 TZ. Thus TZ whose Logarithm is 1.7490360, is foun of 0.5610955 Parts. And LZ is found of 99,4389045 Parts, whose Logarithm is 1.99755642. And as LZ, is to ZF or FT: So is LT, to TY of 4,220071 Parts whose Logarithm is 0.6253196.

14. As TY of 1 Part; is to TS of 178,22270 Parts, whose Logarithm is 2.2509632; so is yͤ other TY of 4,220071 Parts, whose Logarithm is 0.62531965 to the corrected Distance TS, of which the Logarithm is 2.8762828.

15. And as this TS, is to LT; so is the Radius of the Tables, to the Sine of 7° 38' 26; which would be the greatest Elongation once corrected, of the Center of the Moon from the Center of the Earth, as seen from the Distance ST, which is betwixt the Centers of the Sun and of the Earth,

supposing as above the Angle TLS to be changed into a right Angle, and LT to remain of 100 parts as before.

16. Then if with Sir Isaac Newton we suppose the Sun as it were at an infinite Distance from the Earth; and if we suppose the Moon to move in a Circular and Concentric Orbit, we have now found a manifest Distance from, and a notable Amendment to that original Supposition of Sir Isaac Newton, by which he made ST Infinite, or the Parallax of the Sun as it were wholly insensible. And from thence it follows, that there is included, in that, and perhaps in some other Supposition of Sir Isaac Newton, a great and manifest Error.

17. Now this new Parallactic Angle LST must be further corrected, and diminished, by proper Calculations and Approximations.

18. If we fit our Calculation for an equicrural Triangle LST; then, As TS thus corrected, and whose Logarithm is 2.8762828, is to ½ LT: So is the Radius, to ye Sine of ½ LST, equal to 3° 48′ 43″. And the Parallactic Angle LST comes forth of 7° 37′ 25″,6 in an equicrural Triangle.

19. The 60th Part of this number, or rather the 64th Part, would give nearly ye mean Parallax of the Sun, in reference to the Globe of the Earth. Which Parallax deduced from some Suppositions and Data granted by Sir Isaac Newton would be of about 7′.8″,83.

20. But among these Data there is a considerable one which seems exceedingly dubious to me. And that is the great Density which Sir Isaac Newton gives to the Solar Matter; by making it but 4 times rarer than the Mass of Matter

which

which our Terraqueous Globe is composed of. For the small Distance from us of the Center O, about which the Earth seems really to revolve, makes me to conclude that the Sun is far from being so dense as Sir Isaac took it to be. I say the 64th Part, agreeably to the curious Calculation of Mr Jam. Stirling, R.S.S. published in the Philosophical Transactions. For a smaller mean height of the Moon would make the Center of the Earth to fall betwixt the Moon, and the common Center of Gravity of the Moon and of the Earth which is absurd.

21. I have several other Methods for finding the Sun's Parallax; and intend to publish them likewise with their nicest Result. As to the serious and weighty Objections that present themselves against me; I may publish a Catalogue of them, to shew that I am not unacquainted with them. In the meanwhile, I know but one Objection (and that is against one of my Methods only) to which Objection I may not yet give as I think a solid and mathematical Answer; even should the common Center of Gravity of the Solar System be found to fall sometimes or always within ye Orbit of the Moon. But I have some reason to hope yt when I have time to look in earnest for an Answer to yt Objection, I shall likewise find it; if God, to whom alone belongs the Glory, will continue to bless my Studies.

22. No centrifugal Force of the Sun, of the Moon, or of the Earth, can affect this Demonstration; It flows wholly from the Direction of the Line LF; and would subsist equally, if instead of the Fall of the Moon in 2 Minutes time, we should take her Fall for an insensible Space of time, in which none of the 3 Globes might move forward so much as an Inch. For if LH and HI be made to decrease even in infinitum; yet their Proportion will all along remain the same. Nay tho' the 3 Globes were kept at rest, the same Demonstration would subsist.

23. This is a short and unfinished Specimen of

of what may be expected from my other Methods and Demonstrations. For I hope to shew, not only that the Parallax of the Sun is very great; but also to give it, or the means to discover it, to an astonishing and almost incredible Degree of Exactness.

24. Any proper Judge may easily see that ye Sun's Parallax made only of 10½, and even a Parallax of 10", would make the Gravitation of the Moon toward the Sun, greater than her Gravitation toward the Earth. A thing absurd in itself, and contrary to the whole System and to many Demonstrations of Sir Isaac Newton. For then, from the Beginning, the Sun would have stolen away ye Moon from us.

25. The Numbers wch I have now given, want many considerable Amendments. They are as yet the Result of some Principles and Data, which are partly true and partly false. But I intend to bring them hereafter much nearer the Truth.

Lond. July 18, 1737. N. Facio Duillier

Gents. Mag. p. 412

From Gents. Mag. for 1737. Vol. 7. p. 490.

A Demonstration that the Center of the Orb describ'd annually by the common Center of Gravity of the Earth and of the Moon, and improperly called the Great Orb, is vastly nearer to the Earth, and that Orb much smaller, than is commonly supposed.

This Demonstration is drawn from the Smallness of the Fall of the Moon and of the Earth towards the Sun in two Minutes Time.

1. SUPPOSING the periodic or annual Revolution of the Earth, in reference to the fixed Stars, to be performed in her Orbit, in 365 Days, 6 Hours and 9 Minutes; Then in two Minutes Time the Earth would describe in a circular Orbit an Arc of 4″,928040; of which Number the Logarithm is 0.6926749.

2. Now, As 60″ quad. Is to 4,928040 quad. So is 2.6264222 the Logarithmic Versed Sine of 60″, or of 1 Minute in the Tables; To the Logarithmic Versed Sine that would belong to 4,928040 in the Tables, which Logarithmic Versed Sine is found to be 0.4554695. And therefore this is the Logarithm of the mean Fall in 2 Minutes Time, of G ye common Center of Gravity of Earth & of ye Moon toward ye Sun, or toward ye Center O of the Great Orb; taking the Radius GO, or the mean Distance betwixt the Center of the great Orb and the common Center of Gravity of the Moon and of the Earth. But when the Triangle LST is equicrural, the three Falls toward the Sun in two Minutes, or in an insensible Time, of the Moon, of the Earth; and of the Center G, are nearly equal, and the one being found, they are all three known.

Fig. 50.

3. And whereas by Sir Isaac Newton's Theory of the Moon, as amended by what I demonstrate

we

we can have with great Exactness the Fall of the Moon, or of the Earth, and of the Center G in two Minutes Time toward the Sun, in Decimals of the Paris Foot; and since that Fall of G is directed towards O, therefore we shall have the very Radius or Distance GO corresponding to that Fall, with great Exactness in Paris Feet also. And so the Parallax of the Center O being known, we shall be able to correct the whole Theory of the Moon, as well as the supposed Distance betwixt the Centers of the Moon and of the Earth, and even to determine the Parallax of the Sun, and likewise the common Center of Gravity of the Moon, of the Sun, and of the Earth, and the common Center of Gravity of the Earth and of the ~~Earth~~ Moon. For this last Center of Gravity is greatly nearer to the Center of the Earth than Sir Isaac Newton did suppose: As, on the contrary, the common Center of Gravity of the Sun and of the Earth, is a great deal farther from the Center of the Sun, and much nearest to the Earth, than Sir Isaac Newton took it to be.

4. For, if to the Fall LH arising from the base Gravity of the Moon toward the Earth, we add ye little Fall IIh, neglected here by Sir Isaac Newton, and arising from the Sun's Parallax, and from the Obliquity of the Action of the Sun upon L in reference to the Line LT; and if we draw hi parallel to LS (as Exponent of the whole Fall of ye Moon, or of ye Earth, or of the Center G, in two Minutes Time, toward the Sun) we can never suppose that hi might amount to half a Foot, and much less that it might amount to a whole Foot: For according to Sir I. N. As the Radius, Is to 7,6220760: So is LH supposed even of 60,447 Feet, To HI, it would come forth only of 0,23653 of a Foot. But LH is rather of 53,12725 Feet, as being the Fall in two Minutes from the Height of 64 Semidiameters. And this would reduce HI to 0,22294.

5. But as the aforesaid Fall of G, or as the Versed Sine 0,4554693; Is to its Radius 10.00, &c. So is his supposed even of 1 Foot; To 9.5445305 Feet; which being divided by 19615800 Feet; equal to the mean Semidiameter of the Earth; the Quotient would give GO or the Radius of the Great Orb equal to only 170,6 Semidiameters of ye Earth. But ye third Part thereof, or 60 Semidiameters of the Earth, seem to give more exactly ye Radius GO.

6. How amazing, how unexpected is all this; which wholly overturns the reigning and so much applauded System! But when we shall proceed to explain the true Frame and Disposition of the most magnificent Structure of the Solar System, we shall see the divine Wisdom to shine in it with a far brighter Lustre, than in the common System, cloud ed as yet with some intolerable Errors.

7. Sir Isaac Newton, and all our Astronomers and Mathematicians with him, agree that the Versed Sine, of the circular Arc which might be described in a short and given Time, by any Planet or Satellite, or by the common Center of Gravity G, in a concentric Orbit, is the true Measure of their Fall. To increase or to diminish those Versed Sines beyond the Measure which Nature affords, draws after it some Difficulties, from which I could never extricate myself, out by receiving the only true System, and forsaking that, which is inconsistent with itself.

8. In my next I intend, if God permit, to prove, by Sir Isaac Newton's own Principles and inapprehensible Data, That the Gravitations in the Surfaces of the Sun and of the Earth, which he makes to be as 10000 to 435, are rather as 10000 to 100160. A prodigious and amazing Difference! which calls aloud for the Reader's singular Attention.

N. Facio Duillier

Worcester,
Aug. 2, 1737.

Gent. Mag. p. 490. 1737.

279) From Gents. Mag. for 1737. Vol. 7. p. 547.

Some fundamental Inconsistencies demonstrated in the commonly received Planetary System, in order to make Way for determining truly the Sun's Distance or Parallax.

Here the Proportion of the Gravitation in the Surfaces of the Earth and of the Sun is determined.

1. SIR Isaac Newton, p. 405, supposing 10 33 to be the greatest heliocentric Elongation of the Moon from the Center of the Earth (and this probably when the Sun and the Moon are at their mean Distances from the Earth) concludes, by Mistake, That the Gravitations of the same Body, in the Surfaces of the Sun and of the Earth, would be as 10000 to 435; or as 22,9885 to 1.

2. It would have been easy for that Great Man to verify, by his own Conclusions and Determinations, whether the Parallax of the Sun could be so exceedingly little as he does there suppose it to be. For he might have found the Gravitation of Bodies near the Surface of the Sun as follows, independently from the Parallax or Distance of the Sun. But he was wholly prepossessed by the current Opinion of our best Astronomers, who have ever supposed the Distance of the Sun much too great.

3. He determines the mean apparent Semidiameter of the Sun to be of 16′ 6″; whereof the Sine is $^{0}/_{0}$ 6705504. Which Sine, in Logarithms, is to the Radius, as the Unit to 2.3294196, or to 213,5254. And this is the mean Distance ST betwixt the Centers of the Sun and of the ~~Moon~~ Earth, expressed in Semidiameters of the Sun; which therefore amount to about 231 ½ Solar Semidiameters.

Fig. 50. 4. According to Sir Isaac Newton, the Gravitation LT of the Moon toward the Earth, in an equicrural Triangle LST, is to TF or

TY (for it makes no Difference) that is, to the mean Gravitation of the Moon (or of the Earth) toward the Sun: As the Radius LT; To 8. 6228760.

5. But LT, taken for the mean Distance betwixt the Centers of the Moon and of the Earth, cannot be less than of 64 Semidiameters of the Earth, for the Reasons given in the Magazine for July p. 414, No 20. However, lest the Followers of Sir Isaac Newton should complain, and to render the Calculation easier, let us take LT as it would be, if the Distance LT was but of 60 Semidiameters of the Earth. Wherefore the mean Fall of heavy Bodies near the Surface of the Earth being of 60, 447 Paris Feet in 2 Seconds Time; The Fall LH of the Moon at 60 Semidiameters Distance, would be found to be then also of 60, 447 Feet in 2 Minutes Time.

6. But As LT or the Radius, Is to TF or TY, or to 8. 6228760: So is LH, that is, So are 60, 447 Feet, To HI, or to the Fall (of y Moon, or of the Earth, or of the common Center of Gravity G) toward the Sun in 2 Minutes Time in Paris Feet. Which HI comes forth equal to 2, 53659 Feet: A Number which errs rather by being too great than too small.

7. And therefore, by the known Laws of the Decrease of Gravity, As the Square of one Semidiameter of the Sun; Is to 4. 6580992, or to the Square of 213, 525393 Semidiameters of the Sun: So is y Fall HI of 2, 53659 Feet in 2 Minutes Time toward the Sun, at the Distance SL or ST of 213, 5 &c. Semidiameters; To the Fall of 5, 0631499 or of 115651 Feet in y Surface of the Sun in 2 Minutes Time;

8. But the mean Fall of Bodies near the Surface of the Earth 2 Minutes Time is of 60 × 60 × 60, 447 Feet; y^t is, of 217609, 2 Feet, whose Logarithm is 5. 3376772.

9. And by consequence, As 5, 0631499, is to 5. 3376772: Or as 5. 000 &c. is to 5, 2745273 in Logarithms, that is, As 10000, is to 18816: So is the Gravitation in the Surface of the Sun; To the

Gravitation in the Surface of the Earth, even according to the Principles of Sir Isaac Newton. Which Proportion however he makes, p. 405, is 10000 to 435. A prodigious Difference! which shews even to Mathematicians of the meanest Capacity, the amazing Inconsistency of his Numbers.

10. As 435, is to 18816: So is the Unit, to 43,2517: And so many times, that is 43 1/4 times, does Sir Isaac Newton make the Gravitation, in the Surface of ye Sun, greater ~~greater~~ than we have just now found it to be, by making certain Suppositions, even according to his own Numbers.

11. But at the Distance of 64 Semidiameters from ye Center of ye Earth, ye Fall HI would be only of 2,2294 Feet: And by consequence the Fall in the Surface of the Sun would be to the Gravitation in the Surface of the Earth, as 10000 to 21409; or as 4671, to 10000; which Sir Isaac Newton makes to be as 10000 to 435. But this Number 435 must be multiplied by 50 at least, yt ye Product may amount to 21409.

12. I see not how any Man can elude the Strength of this Demonstration; which those that I have published in the two last Magazines do so much confirm: Not to mention those Demonstrations which I hope to publish hereafter. What I have written here does affect greatly the whole Solar System.

13. When we make Use of the equicrural Triangle **LST**, the true Fall of the Earth or of the Moon toward the Sun, in reference to the Exponent **LT** of the Gravitation of the Moon toward the Earth, ought to be expressed by **TY** rather than by **TF**. And this requires a small Encrease of the Radius GO, or of the Great Orb, in favour of Sir Isaac Newton. But this shall be fully considered and accounted for, in another place. N. Jacob Sutton

Worcester,
Sept. 1. 1737.

(Gents. Mag. 1737. p. 547.)

From the Gents Mag. for 1737. Vol. 7. p. 611.

Some Theorems from which the Parallax of the Sun may be deduced, and is here deduced with great Exactness.

1. ON the first Day of July, 1735, it pleased that Divine Providence, which governs all Things, to permit that I should find a most accurate Method for determining the Sun's Parallax a priori: A Word which Sir Isaac Newton used often in that Sense.

2. The Principles which I made use of, in all my Enquiries for that Parallax, were those which that Great Man has so well established, in that Part of his Book which is irreprehensible. Only I made use now and then of some Theorems more.

3. The first Theorem is, That in those Stereographic Maps, where a Terrestrial or Celestial Hemisphere is projected upon a Plan parallel to a Meridian, the Eye being supposed in the Surface of the Sphere; and the Line drawn from the Eye thro' the Center of the Sphere being perpendicular to the Plan of the Projection; All the Angles formed upon the Sphere (where any Circles great or small or their Tangent intersect each other) are equal to the Angles representing them in the Projection. I communicated this Theorem to Others, and particularly to Mr DE MOIVRE, R. S. S. before the Year 1692, and to him I shewed the Demonstration of it.

Fig. 51. 4. The second Theorem is as follows.

Definition. If such a Stereographic Projection, as I have just now described, be extended on all Sides in infinitum, so that it may contain a Representation of ye whole Sphere; And if about each Pole all the Parallels be drawn in it by intire Circles from Minute to Minute, or from Second to Second: and the Whole be turned about the infinite Axis passing thro' the Poles: I call any of the Spherical Surfaces thus formed by an intire Revolution, A Stereographic Sphere.

Second Theorem. In any proposed Stereographic Sphere

Sphere OLP, having its Center C upon the prolonged Axis ST, any two Lines LS, LT drawn from any Point L of that Sphere to the Poles S and T of the Projection, are to one another in one and the same Proportion: And by consequence, If the Centers of the Sun and of the Earth be placed in the Poles S and T; and if the Center of the Moon describe any Orbit, either circular or more compased, while it moves upon the Surface of the Stereographic Sphere OLP, the Lines drawn from the Center of the Moon to the Centers of the Sun and of the Earth, will be to one another in one and the same Proportion.

5. Third Theorem. If, in a Stereographic Sphere OLP, the Gravitations of the Moon towards the Sun and towards the Earth be directly as s the Mass of the Sun and t the Mass of the Earth; and reciprocally as SL quad: and LT quad. that is, if those Gravitations be as $\frac{s}{SL\ quad}$ and $\frac{t}{TL\ quad}$, which is the Case in the Solar System: Then, The Direction of the Two united Gravitations of the Moon will tend to one and the same Focus F, or f, placed somewhere upon the Line or Axis ST, or rather upon the Line PT. And, by consequence, equal Areas will be described about that Focus in equal Times.

6. Fourth Theorem. And in general, If the Gravitations be as s and t directly, and as SL^n and LT^n directly, taking n for any Index whatsoever, affirmative or negative; that is, If those Gravitations be as $s \times SL^n$ and $t \times LT^n$; The Direction of those Two united Gravitations will tend towards, or in oppositum to, one and the same Focus F, or f, placed somewhere upon the Axis ST, or rather upon the Line TP.

7. I communicated also the Sum of these four Theorems to Sir Isaac Newton, in a Letter from London written before the Year 1692. I did hope, even then, that it might serve to find the

Sun's

Sun's Parallax. But when Sir Isaac came to Town, instead of entertaining the same Hope, he only said, That it would serve to determine the Excentricity of the Moon, but that the Revolution about the Sun spoiled all. This made me to neglect that Theorem, till the Year 1735. And such was my Prepossession that when I found by it the Demonstration of an accurate Method for finding the Sun's Parallax, and my Calculation made it them of 2° 26′ 23″ 38‴ in reference to the Orbit of the Moon, I did write over-against my Demonstration; Hic videtur Error subesse, undecunque oriatur. For I could not believe that the Parallax of the Sun was so great. But hitherto I have not been able to find any Paralogism in that Demonstration.

8. Sir Isaac Newton in his 26th Proposition, supposes the Moon to revolve in a circular Orbit concentric to the Earth: and argues upon that Supposition. But I shall suppose that the Center of the Moon does or might revolve, at certain select Times, or in certain Cases, in Orbits which may not depart from a Spherical and Stereographic Surface OLP. Which Supposition will come a great deal nearer the Truth. For by that means I may have a full Regard to the Moon's Excentricity CT. And wheresoever the Focus F or f may fall upon the Line PT, there it will remain fixed, during the whole Revolution of the Moon upon the said Surface. And so that Focus may be placed any where upon PT, according as the Observations, already made or to be made, or the Astronomical Tables, and the Opinions of Astronomers, or the Seasons of the Year, or the Proportions which you allow to the Masses of the Sun and of the Earth, or else to the Lines LH and HI, or LH and HI may require. And at the same time the Gravitations of the Moon toward the Sun S and toward the Earth T will be, in any Point of the Spherical Surface OLP, accurately in the Proportion

of

$\frac{s}{SL^2}$ to $\frac{t}{TL^2}$; as they are really in the Solar System. These inestimable Advantages can=not but seem very great, and lead us to ex=cellent Conclusions.

9. In the Sphere OLP, the Point P is the nearest to the Sun S, and to the Earth T: and the Point O is the furthermost from them.

10. Let SP be called y, viz. the Distance betwixt the Center of the Sun and the Perihelie or Perigee of the Sphere OLP. Let the Radius PC or CO of the Moon's Orbit be called h. And let CT, or the smallest possible Excentricity of the Orbit of the Moon, be called E for the Winter Season, and be called e for the Summer Season, and be called $\mathfrak{e}$, if, when the Centers of the Earth and of the Sun are at their mean Distance, we reduce the Orb of the Moon to a Stereographic Orb.

11. Thus, for any Time when the Center of the Moon may be supposed to describe its Orbit upon the Spherical Surface OLP, or when that Orbit may be made equivalent to an Orbit described upon the Sphere OLP; or when the Center of the Moon touches the Sphere OLP; The Distance of the Sun in Feet, or in Parts of the Radius of the Orbit of the Moon, may be found, and by consequence the Parallax of the Sun also, by saying only, As either of the two smallest possible Excentricities CT, viz. E or e; Is to the Radius CP or h of the Orbit of the Moon: So is that Radius CP, To $\frac{hh}{E}$ or $\frac{hh}{e}$ that is, to the Distance CS, or cs, betwixt the Centers of the Sun, and of ye Orbit of the Moon, expressed at your Choice, either in Feet, or in Parts of the Radius CP.

12. And these two smallest possible Excentri=cities CT, or E and e, are to one another as

$1016\frac{11}{12}$ and $983\frac{1}{12}$; And may be found either by easy and accurate Observations, as I shall demonstrate; or even by Calculations of the Place of the Moon, adapted to proper Suppositions and Times, and also by former or future Determinations of Astronomers. And at the same rate, the Excentricity e would be 1000.

13. Now as CS, that is $\frac{hh}{E}$ or $\frac{hh}{e}$; Is to CP or h: So is r, the Radius of the Tables, to $\frac{rE}{h}$ or $\frac{re}{h}$: which is the Sine of ye Parallax of the Sun in reference to the Orbit of the Moon, or the Sine of the greatest Elongation of the Moon from the Center of the Earth, as seen from the Center of the Sun, when the Line drawn from the Center of the Sun, to the Center of the Moon, is a Tangent of the Stereographic Sphere OLP, or olp.

14. Likewise, supposing that the Proportion of the Lines CT and TS is determined, as it is indeed in Nature: Then, $\frac{1}{ST^2}$, Is to $\frac{1}{SC^2}$; As TF or Tf, made Exponent of the Gravitation in the Region of the Earth and of the Moon towards the Sun, Is to $\frac{TF}{SC^2}\times ST^2$; or to $\frac{Tf\times ST^2}{SC^2}$; that is, To the correspondent Exponent of the Gravitation in C towards the Sun. Which Gravitation being also as $\frac{1}{SC^2}$; by the know Propriety of Gravity: it follows, That $TF\times ST^2$ or $Tf\times ST^2$ is a determined Quantity; and that, by consequence, TF or Tf is reciprocally as ST^2. And so TF or Tf may safely be made the Measure or Exponent of the Force by which the Earth and the Moon and their Common Center of Gravity are drawn toward the Sun, in an equicrural Triangle LST, by the bare Force of their Gravitation toward the Sun.

15. And if the Proportion of ST to CT be determined, or else be chosen at discretion; And then TF or Tf be found or supposed greater or smaller: This would argue that the Sun has, in

the

the same Proportion, a greater or smaller Density.

16. In the same manner, $\frac{1}{ST^2}$; Is to $\frac{1}{SC^2}$: As TY or Ty made Exponent of the Gravitation in the Region of the Earth and of the Moon towards the Sun, To $\frac{TY \times ST^2}{SC^2}$, or To $\frac{Ty \times ST^2}{SC^2}$; that is, To the Correspondent Exponent of the Gravitation in C towards the Sun. Which Gravitation being also as $\frac{1}{SC^2}$; It follows that $TY \times ST^2$ or $Ty \times ST^2$ is also a determined Quantity; And that by consequence TY or Ty is reciprocally as ST^2. And so TY or Ty, as well as HI or HK, or else as hi or hk, may safely be made the Measure or Exponent of the Gravitation of the Earth or of the Moon towards the Sun; in whatsoever Point the Focus F or f may be placed upon the Line PT. And all this, as I have said already, depends upon the greater Density or Rarity which we shall find to belong to the Solar Matter, supposing the Sun to remain at the same Distance from the Earth.

17. But supposing that the Distance of the Sun does alter, as it does ~~all the~~ throughout the year; Then the Sine of the Parallax of the Sun placed in ſ, in reference to the Orbit of the Moon, would be reciprocally as the Distance cſ betwixt the Centers of the Sun and of the Orbit of the Moon. And likewise cT would be reciprocally as the Distance cſ; since cT is to CP as CP to cſ. Therefore cT, which is always a Natural Sine in the Sphere olp, having now its variable Center in c, would always be the Sine of that Parallax of the Sun, taking for Radius CP or cp, or the Radius of the Orbit of

of the Moon. And by consequence; In any Cases where the Proportion of cT to cp or CP is known, whether in Feet or in Parts of the Radius CP or cp; There will also be known the Parallax of the Sun in reference to the Sphere olp: And we have it ready calculated at hand, in the Tables of Natural Sines; as may be seen in the following Table.

18. And indeed; if upon SC or ſc we erect the Perpendicular TQ or Tq cutting the Sphere OLP or olp in Q or q; and if from Q or q we erect a Perpendicular upon SQ or ſq; That Perpendicular will paſs thro' the Center C or c: And SQ, or ſq will be a Tangent of the Sphere OQLP or oqlp. For, in the Circle whose Diameter is CS, or cſ, The Tangent SQ, or ſq; Is to QT, or to qT; perpendicular to SC, or to ſc: As the Radius; To the Sine of the Parallax QST, or qſT. And by consequence CQ, or CP; Is to CT; and cq, to cT: As the Radius; To the Sine of the Parallax QST, or ſqT.

19. And if we take for Radius CP, or ye Semidiameter of the Orbit of the Moon; Then ye two smallest poſsible Excentricities E and e, expreſsed in Parts of that Radius, being sought for in the Table of Natural Sines, will give there the Natural Sines of the Parallaxes of the Sun, in reference to the aforesaid Spheres OLP or olp. Thus CT the smallest poſsible Excentricity equal to 4332,267$\frac{2}{3}$ (derived from Sir I. Newton. p. 462) gives in the Table that Parallax of the Sun of $2' 28'' \frac{2845}{2906}$. Which Excentricity he and Mr Whiston ought to have given in two very different Numbers, viz. for Summer and Winter; if their Numbers were as they should be: Since from them ought to result the Summer Parallax and the Winter Parallax; whose Proportion is nearly as 983$\frac{1}{12}$ to 1016$\frac{11}{12}$.

20. Likewise the Second Excentricity TF or Tf, (viz. the Distance between the Center of the Earth and the Focus F, or f, of the Orbit of the Moon, which Second Excentricity is also double, for Summer & Winter) That Excentricity TF or Tf, variable throughout the Year, depends wholly upon the Density of the Sun, which must needs be proportional to the Fall HI or HK, while the Distance ST and the Bigness of the Sun are supposed to remain unchangeable, and the Triangle TLS to be rectangular: Or else must be proportional to the Fall hi or hk, if the Triangle TSL be supposed equicrural.

21. That Fall HI or HK, or else hi or hk, is ~~is~~ ever proportional to $\frac{1}{ST^2}$ and has, by consequence, its Exponent proportional also to the natural Sine of the Sun's Parallax, both in reference to the Sphere OLP or olp, and in reference to the Globe of the Earth; while the opposite Excentricity E, or e, continues to be one of the two smallest possible Excentricities; or while the Equicrural Triangle LST, or the Rectangular Triangle SLT remains the same or unchangeable: But the Density of the Sun and the Radius of ye Great Orb do change, in the same Proportion ~~f~~ as HI or HK or else hi or hk is supposed to change.

22. And contrariwise, If the Parallax of the Sun, in reference to the aforesaid Sphere OLP, be of Two Degrees and 17′, or 2° 21′, or 2° 25′, &c. Then the smallest possible Excentricity CT must be, by the Table of Natural Sines, of 3984,11, or 4100,37 Parts, &c. as in this short Table.

2°	17	3984,11
2	21	4100,31
2	25	4216,63
2	29	4332,88
2	33	4449,12
2	$25\frac{114}{2906}$	4220,00
2	$26\frac{198}{2906}$	4265,5
2	$28\frac{221}{2906}$	4331,9
2	$28\frac{284,5}{2906}$	$4332,2\frac{2}{3}$

4220,00 To Mr Wright, who corrects a Mistake in Gregory's Astronomy.
4265,5 seems to be the least Excentricity to Mr Wright, p. 25, l. 33.
4331,9 To Mr Gregory in his Astronomy, and to Sir I. Newton.
$4332,2\frac{2}{3}$ To Sir Isaac Newton, p. 462.

This Table supposes that when the Centers of the Earth and of the Sun are at their mean Distance, the Orb of the Moon be reduced to a Stereographic Sphere. And from thence we may estimate also the Sun's Parallax for Summer and Winter; till it be accurately determined by actual Observations. I purpose to shew hereafter how this may be done.

23. If God permit, I intend to give in my next Discourses the Demonstrations of the first and second Theorems mentioned above, No 3 and 4: And from them to deduce the most perfect Method of finding the Sun's Parallax, and to give an Example how to calculate it. And then I purpose to go on, to rectify an Error incident to the Observations of fixed Stars eclipsed by the Moon. An Error, I say, unavoidable to our best Astronomers, but by

an Equation unknown to them, and grounded upon a certain natural Cause which they have never described. That Equation is so considerable, that in Calculations, tho' otherwise most accurate, and amended by the Tables which y^e Publick expects from the indefatigable Pains and Industry of Dr Halley and of Mr Professor Bradly; yet this natural Error to which are liable y^e Calculations built upon Observations made at Land or at Sea, might amount even to some Degrees, in the Determination of the Longitude of the Place of Observation.

24. The utmost Diligence and Accuracy will be required in establishing every one of the Data which must enter our Calculations, unless we chuse to leave the nicest Determination of the Sun's Parallax to the Industry and Diligence of another Age.

N. Facio Duillier.

Worcester,
Oct. 5, 1737. (Gents. Mag. p. 611. 1737)

From Gents Mag. for 1737 Vol. 7. p. 616.

To find the Longitude at Sea without Instruments.

Fig. 52.

One may judge his Longitude within 4 Deg. or the Time at London within ¼ of an Hour, which will give N the Place of the Moon's Node within 2 Seconds, its mean Motion being but 3 Min. 11 Secon. in 24 Hours, and to find its R. Ascension, and the Hour by it before 6 (i.e.) the Angle EPN, wch, with EP, and the Latitude PER, gives PB or BN, and also PBE or EBN, which two, with PNC, the Angle made by the Moon's Path (which makes about 5 Deg. with Eclip.) and its Meridian then, gives Nn, but the Moon's Center at rising is found, by substracting the Refraction from the Parallax, suppose it to be 24 Min. above the Horizon or the Center c, 9 Min. (the ½ Diam. being 15); then co being 9 Min. that, with the Angle n, gives cn to be added to nN, and you have the Distance of the Moon's Center then from the Node N, whose Place was before found, and having done so before at the Place departed from, where the Longitude was known, you have the 2 Distances from the Node, and by substracting the one from the other, and the Min. the Node hath moved from the Remainder, you have found the Arch in the Moon's Path thro' which the Moon hath gone since you left the first Place, and beginning at the mean Anomaly answering the Moon's first Place, count up its horary Motions till you make up the Deg. the Moon hath moved, changing the horary Motion every 6 Deg. the Tables being only made for each 6 Deg. the Hours and Min. answering these horary Motions being added to the Time at London, gives the Hour there.

Note

Note. Tho' the 2 mean Anomalies answering the 2 Places of the Moon should be, on account of an Error in the Apogee, half a Degree wrong in their Distance, yet that will not cause an Error above 2 or 3 Seconds of Time in the Sum of the horary Motions, and tho' the Error were 60 Seconds or a Minute, that makes but an Error of 15 Miles, and the Act of Parliament allows an Error of 60 Miles. So that if the Sum of the horary Motions be right to 4 Min. of Time, he hath a good Title to the Premium.

But because the Moon may be sometimes near 90 Deg. from the Node (and she cannot be more) in which Case the horary Motions may be too many to be added, therefore having found her Place at a known Longitude, suppose on Dec. 10, at 0 o'Clock, If I add her periodic Revolution (rectify'd from the Place of the Earth, the Apogee, and Node) I shall have her in the same Place again in January at a certain Time, and if to that Time I add her periodic Revolution rectify'd, I shall have her there again at another Time in February, and so throughout the Year. And having found her Place likewise the 12th of Dec. at 9 o'Clock, I add her Period again, and I have her in Jan. at another Time, and so in Feb. throughout the Year. A Table being thus made of her Place and Time, if I find her at Sea in any of those Places, or near them, Then as her horary Motion is to the Difference of your Place and that in the Table, So is an Hour to a 4th to be added or substracted to the Time in the Table (according as you are short of or exceed the Place in the Table) and you have the Hour at the know Longitude, Thus there is no need of the Equations of the Moon's Center, and of the Variation, or the 6th and 7th

Equa=

Equation in Sir Isaac's Method, one of which he speaks of doubtfully, which may be the cause of an Error of some Min. in the Moon's Place, which I have all along allowed, being it can make but an Error of 2 or 3 Seconds in the Moon's Parallax or horary Motion.

(Gents. Mag. 1737. p. 616.)

Considerations on the offices and extent of GEOMETRY and MECHANICS, NATURAL PHILOSOPHY, &c. designed to class & point out the particular sorts of errors, in each. & to be published in the gentlemans Magazine; when I can get time to finish & transcribe it.

GEOMETRY is that science which shews and investigates the various properties, and the different relations of all sorts of lines, angles, and figures both superficial and solid ~~figures~~, respetively, among themselves;* to which alone it is confined, without any application to other matters. Algebra and fluxions do the same with letters substituted for the several lines, angles, and figures; and are also confined to ~~have also~~ the same limits.

We begin each by assuming and clearly describing the most simple, plain and easy præcognita or premises; which are commonly such of these properties and relations as carry a kind of occular proof with them; they are therefore admitted upon the evidence of sense; the descriptions under the term of definitions, and the properties or relations themselves under those of axioms ~~or~~ & postulates.— These ideas, acquired ~~by~~ from external objects by our senses, being once assumed as a standard for the truth of all others in these sciences, help us to discover the intermediate ones, ~~which may~~ by shewing the agreement, disagreement or repugnancy of ~~others~~ those ~~that~~ which cannot be immediately compared, until we obtain a true judgment of the several remote properties and relations desired. ~~All the Each several property or relation~~ Each of which, leading from these self-evident ones, or from some other well established ~~from~~ on them, to the quesita, ~~are~~ is thus brought to its standard, compared

* Those who make magnitude or quantity the subject of geometry in their general acceptations, as most authors ~~have~~ hitheto ~~do~~, have done, is ~~ascribing to~~ extending geometry to too great a latitude, and ascribing more to it than it can well bear; for this runs into the application, & has misled many by too hastily applying geometry to all sorts of magnitude & quantity. See Simpson's & Emerson's Definitions

compared, measured, and tried, as the draper brings all his measures to the standard yard; the silver Smith all his weights to the standard ounce; and like them we withhold our assent from every thing which does not perfectly agree with our standard; and admit those only for turth which are greeable to it: and these again are often used for the standard of others; thus we proceed from step to step either to a more compound and difficult case, ~~called the~~ according to the method of Synthesis, or to a more simple and plain one, according to analysis, by a chain of well connected reasoning which cannot be denied, until we arrive at the conclusion desired; and this, in the synthetic method, is ~~called~~ generally called a theorem.

This is geometry, algebra and fluxions in the abstract, which can never be false while all the steps of the process are well preserved; and as these several lines, angles and figures are generally objects of sense, we cannot easily be mistaken, but the theorem, or result, will carry with it the highest evidence our reason is capable of, when not assisted by revelation; and the process may fairly bear the name of demonstration; for a demonstration is strictly confined to the abstract, and cannot, with any sort of propriety, be applied or ascribed to any other evidence; tho' scarcely any one term, throughout the whole circle of the sciences, is more abused & misapplied, by ascribing it to every trifling and probable evidence, either in practice or speculation. If we should once break the chain of our reasoning, and introduce one false step into our process, all the following, ~~will be~~ which depend upon it, will be false. This is what I would call an error in the abstract, or a geometrical, algebraical, or fluxionary error; and the interruption ~~may~~ will appear in many instances by ~~pursuing~~ ~~the same or~~ aiming ~~at the~~ with other or the like steps ~~the~~ (pursuing) same conclusion, in a different way, or by considering the like properties or ratios in different cases; and this ~~which~~ will not only point out the error by leading us into a contradiction, but even correct it by exhibiting the truth.

These sciences, whose peculiar province is in the

abstract, will therefore correct an error, which alone belongs to them, but no other; they are consequently limitted within their own proper bounds of abstraction, and there is no such thing as practical geometry, algebra, and fluxions, but what is contained in and confined to the abstract; though we sometimes meet with them imposed upon the public in another sense.

Hence it appears that every thing in these sciences becomes known à priori, or is the production of the human mind by reason alone, without the knowledge and assistance of any effect from a prior cause.(*) ~~And I believe~~ this way of reasoning à priori will, I believe, be found peculiar to, and the distinguishing characteristic of all sciences, strictly so called, though it is unobserved by ~~any writer~~ all the writers I have met with, who reckon the seven liberal sciences, to be grammar, logic, Oratory, arithmetic, geometry, astronomy and music; but I cannot subscribe to astronomy as such, because all our knowledge of it is not à priori but à posteriori.

(*) They lying thus open and free to the reason of every man, and at liberty to be embraced by all, have obtained the epithet of liberal, and are called the liberal sciences.

On the contrary; In mechanics, astronomy, ~~and~~ natural philosophy, and all the other arts; where the manner of operation is invisible, and the physical cause ~~lies~~ of any effect does not fall under the cognizance ~~lies beyond the reach~~ of our senses, we have no ground, ~~to~~ no standard, to reason à priori, as in the sciences; we can no more comprehend these invisible operations, or have any knowledge of physical causes, than a blind man can of colours, a deaf man of sounds, or one who has lost the sense of smelling can judge of odorous effluvia; for the former are no more the object of our senses than the latter are of those who want the peculiar senses to discern these. We therefore, having no previous data, cannot discern in what particular manner or which way these causes operate, nor can we form any judgement of the causes themselves, but by their effects. The method of proceeding therefore in these arts, ~~must~~ can never be by induction

Ludlam's Prob. I. p. 126 truly investigated. See p. 262.

~~Let KE, Fig. 51. represent the direction and force or power of the tooth E, acting~~

Let KE, Fig. 51. respresent the force or power impressed upon the tooth E, by the third great wheel, and draw PK perpendicular to PE, the plane of the pallet's face; the rest of the lines not hereafter described, are drawn as in his figure.

See p. 261.

1. It is evident that E will exert ~~part~~ itself against the plane PEL with part of its power only, in the direction KE, perpendicular to EC, and endeavour to drive it in the direction EB, perpendicular to PEL. To find the power of this tension in the plane; by the true method of resolving forces, PE : PK :: KE : PZ, that part of the power KE, with which PEL is exerted in the direction EB; and :: PE : PH, the other part of the power KE; which, being parallel to the pallet PEL, has no effect to move it; and is therefore lost and annihilated.

2. Make BE = PZ, and suppose the plane of the pallet to resist this action of E against it, it can exert that resistance no where but upon C the center of the swing wheel. This resistance will be in the direction of, and equal to, BE; to find thence the power impressed upon C; Let BD be perpendicular to CE produced. Then, per true method of resolving forces, ED + DB : BE :: ED : ES, the pressure or power upon C.

3. Let ES, upon the line EB, be = ES upon the line ED. It is manifest that this power upon C diminishes the power EB, by which the plane PEL would have moved in the direction EB, applied at right angles, and on the same side with KE; so that only the power ~~=~~ (EB − ES =) SB is really communicated to the plane. Make Eb = SB, and draw bF ~~perpendicular to~~ parallel & EQ perpendicular to AE: Then Eb will express the tension of the plane in the direction EB. To find the power impressed upon A, by this tension. per true mechanics, as before, EF + Fb : Eb :: EF : ET, the pressure or power upon A.

4. ~~Make Et =~~ It is likewise clear and evident, that this power impressed upon A also diminishes the power Eb, with which the plane PEL would otherwise have endeavoured to move in the direction EB. Make ET, upon the line E~~B~~ equal to ET upon the line EQ; then Eb − ET = Tb; make Et equal to it, and Et will express the tension of PEL in the direction EB. But since PEL is at liberty to move only in a circle round A, this direction in an

an imaginary one; and the power Et with which the plane ~~would~~ endeavours to move in that direction, must be reduced to the direction EQ, perpendicular to EA. Therefore draw dt perpendicular to EB; and EQ made equal to Et + dt, will express a power which shall have the same effect upon the plane PEL in the direction QE, as Et would have in the direction BE; and consequently a power impressed upon PEL, equal to and in the direction QE, will sustain the whole in equilibro, as Mr. Ludlam proposes.

Cor. since the proportion in all these operations are as the Sum of tangent and radius : the secant :: tangent or radius : radius or tangent, this fourth term will exceed the second at all angles, except when EC is perpendicular to PEL, when all four terms will be equal, and no power communicated to the plane, it being exerted in a parallel direction. Hence, when ~~all~~ the weight and friction of all the materials are excluded, it follows, that the least power, acting in any direction, will move the pallet.

Schol. Hence it necessarily follows, that the sum of the several powers Et, equal to the effect EQ, upon the plane PEL; ET, ES, sustained by the two respective centers A, C; and PH, the power annihilated by the oblique direction against PEL, will make up the original power impressed upon the ~~two~~ tooth E, from whence they all arise. Whereas by the present received principles of Mechanics, this sum may be a thousand or ten thousand times the original power in E; notwithstanding this alone, without any additional increase, gives birth to all the rest; that is, any one finite small power may produce and communicate any number of finite large powers, by only losing part of itself and dividing the remainder.

An Algebraic Solution

1. Put T and t for tangents of the given angles CEL and AEL respectively; and p for the power of the tooth E.

Then in $\triangle$ PEK. per true principles of Mechanics, $T+1 : p :: 1 : \frac{p}{T+1} = PZ$, the pressure upon PEL; $:: T : \frac{T}{T+1} = HE$, the power lost or annihilated.

2. In $\triangle$ EDB, make BE = PZ. Then, per mechanics, $T+1 : \frac{p}{T+1} :: T : \frac{pT}{\overline{T+1}|^2} = ES$, the pressure upon C. And EB − ES, upon the line EB, = BS, i.e. $\frac{p}{T+1} - \frac{pT}{T+1} = \frac{p}{\overline{T+1}|^2} = BS$, the ~~exp~~ remaining power upon the plane PEL.

3. In $\triangle$ FbE, make Eb = BS, and draw bF per=

perpendicular to EQ; then per mech. $t+1 : \frac{p}{\overline{T+1}^2} :: 1 : \frac{p}{\overline{T+1}^2 \times \overline{t+1}} = ET$, the pressure upon A, which subtracted from Eb, leaves $\frac{pt}{\overline{T+1}^2 \times \overline{t+1}} = Et$, the power with which the plane endeavours to move in the direction EB.

4. Since the plane PEL can only move in a circle round A, EB is an imaginary direction; and therefore this power Et, must be reduced to the direction EQ, perpendicular to EA; whence, per mech. $1 : t+1 :: \frac{pt}{\overline{T+1}^2 \times \overline{t+1}} : \frac{pt}{\overline{T+1}^2} = Et + td = EQ$, a general theorem for the power acting against the plane PEL, in the direction QE to sustain the whole in equilibrio.

2. E. F.

Cor. 1. As the distances of A and C from E are not concerned, they may be assumed at pleasure, so that A is perpendicularly over C.

Cor. 2. It appears that the less T is in respect to t, the greater will the effect EQ be upon the rod of the pendulum.

Example

Suppose the $\angle$CEL $= 59\frac{1}{2}^{\circ}$ and AEL $= 51\frac{1}{4}^{\circ}$, (as I measured them in Ludlam's figure) and the tooth E endued with a power equal to 6 Ounces.

A general Trigonometrical solution

by supposing $p = 1$. & The red figures are those next above them × 6 Ounces for this particular example.

1. In $\triangle$ PEK, PE+PK = 2,6976631 Log. Co Ar. $\overline{9}$,5690123
: 1 = p :: 1, Rad. : PZ - - - - - - - - - = ,3706912 = BE
2,2241472

and PE+PK − PZ = HE ---- = ,6293088
3,7758528

2. In $\triangle$ DBE, BE = PZ; & BD+DE = 2,6976631, Co Ar. $\overline{9}$,5690123
: BE = ~~1,6~~ 0,3706912 Log. 9,5690123
:: DE — = 1,6976631 Log. 0,2298515
: ES = ,2332793 ——— $\overline{9}$,3678761
1,3996758

3. In $\triangle$ FbE, EB − ES = Eb = ,1374119. & EF+Fb = 2,2459742
Co Ar. $\overline{9}$.6485952
: Eb = ,1374119 ——— $\overline{9}$,1380243
:: 1 = EF : ET = ,06118142 – $\overline{8}$,7866195
,36708852.

4. In $\triangle$ Edt, Eb − ET = Et = ,0762305, and
,457383

1 Rad. : Et = ,0762305 Log. $\overline{8}$,8821287
:: Et+1 = 2,2469742 Log. 0,3514048
: Et + td = EQ = ,1772118 — $\overline{9}$,2335336
~~,4922496~~
1,0272708

Whence The power HE annihilated = ,6293088 — 3,7758528
The pressure upon C = ES — — ,2332793 — 1,3996758
- - - - - - - - - - A = ET ——— ,0611814 — ,3670886
- - - - - - - - - - - the Plane PEL = Et ,0762305 — ,4573383

Sum equal to the Original power = — 1,....... 6,.......1

But Et reduced into the direction EQ, it becomes = EQ = ,1712118 — 1,0272708

And ES + ET + Et = PZ = BE, The pressure sustained by the tooth E, } = — — ,3706912 — 2,2241472

According to Ludlam's computations

DB = 1 given to (not by) the Wheel or tooth E.

FE = 1,233254 pressure upon A.
DE = 1,697663 D° upon C.
FB = 1,536602 D° upon the back of the pallet

4,467519 Sum of the 3 last; which ought to have been equal to DB = 1.